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Assessing New Zealand public preferences for native biodiversity outcomes across habitat types: A choice experiment approach incorporating habitat engagement

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Research Report No. 345

December 2017

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Suggested citation for this report:

Tait, Peter, Caroline Saunders, Sini Miller, Paul Rutherford, Glen Greer and Walt Abell (2017). *Assessing New Zealand public preferences for native biodiversity outcomes across habitat types: A choice experiment approach incorporating habitat engagement.* Research Report No. 345, Lincoln University: Agribusiness and Economics Research Unit.

Assessing New Zealand public preferences for native biodiversity outcomes across habitat types: A choice experiment approach incorporating habitat engagement

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ISSN 1170-7682 (Print)
ISSN 2230-3197 (Online)
ISBN 978-1-877519-54-3 (Print)
ISBN 978-1-877519-55-0 (Online)

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Acknowledgements

The AERU thanks the following for their assistance with this project:

Graham Nugent, Wildlife Ecology and Management, LandCare Research Ltd.

Bill Lee, Biodiversity and Conservation, LandCare Research Ltd.

Peter Bellingham, Ecosystems and Global Change, LandCare Research Ltd.

Andrea Byrom, Director Biological Heritage National Science Challenge, LandCare Research Ltd.

Duane Peltzer, Ecosystems and Global Change, LandCare Research Ltd.

John Saunders, Agribusiness and Economics Research Unit, Lincoln University.

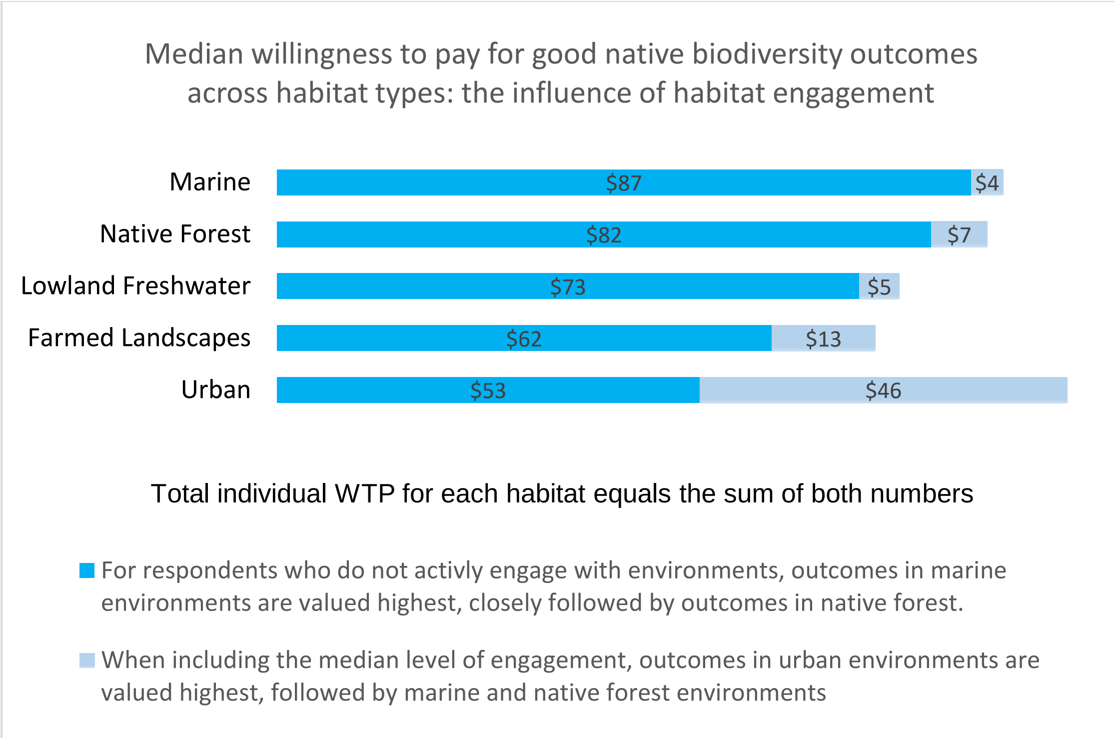
Meike Guenther, Agribusiness and Economics Research Unit, Lincoln University.

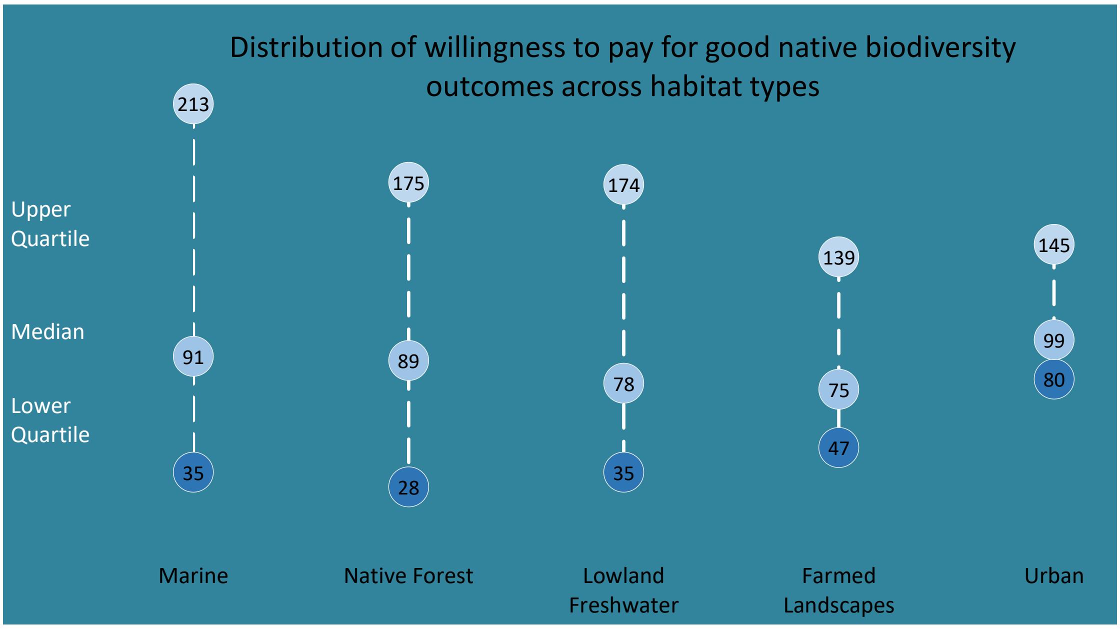
Mark Anderson, Department of Informatics and Enabling Technologies, Lincoln University.

Michael Burton, School of Agricultural and Resource Economics, University of Western Australia.

Key Points

- A central policy priority for New Zealand national biodiversity strategy concerns the protection of indigenous habitat within highly threatened environments. However, comparison of New Zealand's protected areas with threatened environments suggests that the current budget-constrained allocation of management resources is scarce in the most threatened habitat environments, such as urban and farmed landscapes.
- The development of management effort prioritisation between protected and threatened environments could be practically informed by expanding current understanding of public values for native habitat outcomes in these environments. In the first New Zealand application of its kind, this report presents an economic assessment of public values for native habitat outcomes across threatened and protected environments through the application of non-market valuation method. We assess public values for native biodiversity outcomes across urban, lowland freshwater, native forest, farmed landscape and marine environments.
- While the direct costs associated with native biodiversity management are observable in market transactions, such as the costs of pest control, many of the benefits do not have associated market signals with which to measure the value of native biodiversity outcomes. A non-market valuation methodology, Choice Experiments was therefore used.
- This report details the development and application of a Choice Experiment by the Agribusiness and Economics Research Unit at Lincoln University and LandCare Research Ltd to identify and measure New Zealand resident's preferences for native biodiversity outcomes across different threat level environments where management effort could be applied.
- The Choice Experiment involved an online survey of NZ residents in November 2015, using a research panel, of 985 residents and achieved a good representation of key population demographics.
- The Choice Experiment shows that respondents place substantial value on native biodiversity outcomes. 90 per cent of respondents are willing to pay something to improve native biodiversity outcomes above current levels.
- We collected GIS data on respondent's level of engagement with each environment type, where-they-go, and what-they-do, and use this information to condition modelling of willingness to pay values. In the last 12 months the median respondent engaged in activities in:
- Urban environments 46 times; Marine environments 10 times; Native forest 9 times; Lowland freshwater 3 times; Farmed landscapes 25 times
- Modelling shows that the number of times respondents engage in each environment type is a key determinant of their preferences for native biodiversity outcomes in those environments. The influence on preferences is found to strengthen as engagement levels increase.





- Public preferences are ***most*** diverse for native biodiversity outcomes in marine environments. Suggesting a relatively larger degree of disagreement over management outcomes.
- Conversely, preferences are ***least*** diverse for native biodiversity outcomes in urban environments. Suggesting a relatively larger degree of consensus for management outcomes.

Chapter 1
Introduction

This report details the development and application of a Choice Experiment (CE) used to identify and measure New Zealand resident's preferences for native biodiversity outcomes across different environments where management effort could be applied. The CE method was the primary tool employed to achieve our objective; to determine, in economic terms, the value of some of the non-market benefits to native biodiversity.

New Zealand is home to much unique native flora and fauna that provide significant public and private benefits. Consumers in our export markets value native biodiversity as part of the 'clean and green' brand. Likewise, tourists value the 'natural' experience which our native biodiversity provides. To the wider New Zealand public, recreational opportunities and aesthetic benefits are placed alongside the role that native biodiversity has in forming our cultural identity.

New Zealand tax funds a range of native biodiversity management efforts throughout the country including the establishment of formally managed native areas. These include public conservation land, regional parks, local council reserves, and covenants on private land. Areas managed for protecting and enhancing native biodiversity habitat have been established across a range of environments. These are predominantly in areas of native forest, but do include other environments, although to a much lesser extent, including urban, freshwater, marine, and also in farmed landscapes (Fig 1).

An examination of Protected Areas Network NZ[1] (PAN-NZ) and Land Cover Database[2] (LCDB v4.1) indicates a coverage of approximately 7 per cent of the urban area within PAN-NZ, 37 per cent of lowland freshwater, 3.4 per cent of farmed landscapes and 69 per cent of native forests. Within the marine environment, Department of Conservation (DoC) Marine Reserves[3] and Marine Mammal Sanctuaries[4] provide a total area of management of 32,009.5 km², or 0.80 per cent of the NZ Exclusive Economic Zone[5].

An indication of the current extent of pressure on native biodiversity is provided by the Threatened Environment Classification[6] (TEC). The TEC uses indigenous vegetation cover as a surrogate for indigenous biodiversity and provides information on the loss and protection context of indigenous biodiversity on land that can be used to assist identification of management priority areas.

Comparing the TEC and PAN-NZ maps reveals that, in general, unprotected areas are most at threat. Within a national context of increasingly competing demands for a limited management resource, a central research question in NZ biodiversity management concerns the allocation of limited management resource efficiently across the portfolio of programs across these environments. A central objective of this report is to apply the economic method to aid biodiversity decision makers in addressing this research question.

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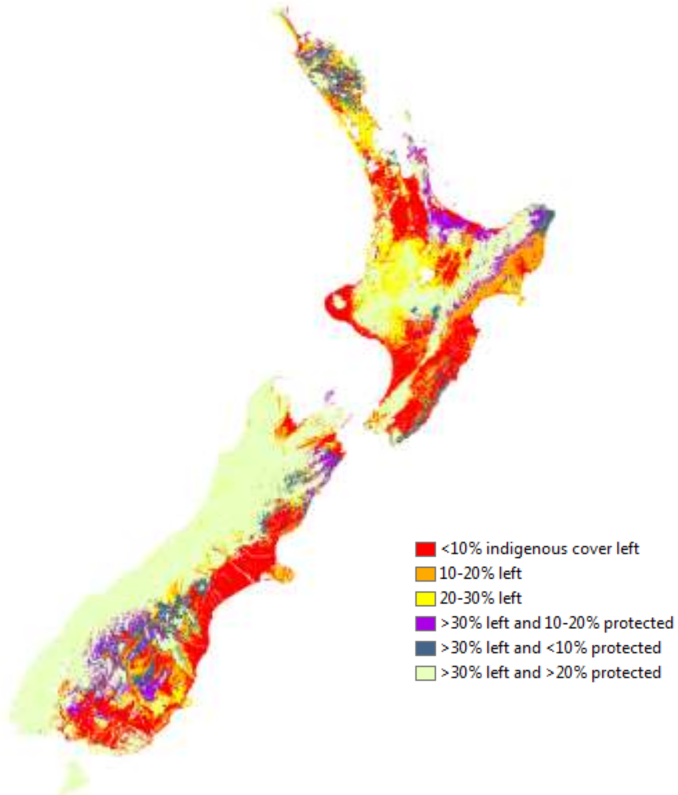
[1] http://www.landcareresearch.co.nz/resources/maps-satellites/pannz
[2] https://lris.scinfo.org.nz/layer/423-lcdb-v41-land-cover-database-version-41-mainland-new-zealand/
[3] https://koordinates.com/layer/6026-doc-marine-reserves/
[4] https://koordinates.com/layer/6025-doc-marine-mammal-sanctuaries/
[5] http://www.linz.govt.nz/about-linz/what-were-doing/projects/new-zealand-continental-shelf-project/map-continental-shelf
[6] http://www.landcareresearch.co.nz/resources/maps-satellites/threatened-environment-classification

PAN-NZ (Green) & Marine Protection (Blue)



Threatened Environment Classification

Figure 1.1: Protected Areas Network NZ and Threatened Environments

Designing economically efficient biodiversity policy requires a consideration of the benefits and costs of policy implementation. While measurement of costs, such as pest control, are relatively straightforward to obtain through observed market transactions, a lack of corresponding market transaction data makes valuing native biodiversity outcomes and quality improvements in economic terms more difficult. The CE method has been applied previously internationally in the biodiversity arena to estimate public values of biodiversity outcomes. Recent application valuing benefits of improved biodiversity quality under the European Natura 2000 network policy[7], and Sites of Special Scientific Interest policy in England and Wales[8] demonstrate the contribution of the method to policy benefits analysis.

We used a CE approach involving an online survey of the public. The project comprised seven main phases.

1. Identification and definition of native biodiversity outcomes across landscape types.
2. Literature review identifying approaches to CE design relevant to the objectives, particularly on the construction of generic values at a national level.
3. Development of the CE questionnaire, combining literature review findings with stakeholder workshop discussion, community focus groups, and results of cognitive interviews with the general public.
4. Administration of the resultant CE survey to a representative sample of New Zealand residents using an online mode.
5. Analysing data employing appropriate econometric models.
6. Estimation of monetary values that residents have for biodiversity quality outcomes.
7. Reporting.

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[7] Hoyos et al. 2012. Valuing a Natura 2000 network site to inform land use options using a discrete choice experiment: An illustration from the Basque Country. Journal of Forest Economics 18, 329-344. http://dx.doi.org/10.1016/j.jfe.2012.05.002.

[8] Christie M. Rayment M. 2012. An economic assessment of the ecosystem service benefits derived from the SSSI biodiversity conservation policy in England and Wales. Ecosystem Services 1(1), 70-84.http://dx.doi.org/10.1016/j.ecoser.2012.07.004.

Chapter 2
Method

2.1 Choice Experiment Method

The selection of suitable economic measurement tools to value native biodiversity policy benefits is driven primarily by the availability of appropriate data that can describe the value of policy outcomes to individuals. There are no observable market prices available that reveal what New Zealand residents are willing to pay for native biodiversity quality improvements. We, therefore, employed a non-market valuation methodology, of which CE was deemed appropriate[9]. The CE method simulates market observations by creating a hypothetical market scenario within a survey that enables people to indicate their preferences for changes in native biodiversity outcomes and the associated costs to them. In this way, a CE produces information on quantities and prices similar to what is found in observed markets which can then be analysed to measure the benefit of changes in biodiversity outcomes. The method is grounded in the same Welfare Economics framework that facilitates the use of observed market prices to measure changes in the value of benefits and costs. CEs have, for over four decades, been applied in economics to value a wide variety of goods and services such as in transport, cultural heritage, environmental quality and health care. This approach has been widely applied to value biodiversity outcomes internationally and has an established New Zealand literature.

CEs are a survey-based method in which respondents are presented with a series of choice tasks. For each choice task, respondents choose between at least two broad options. In this study, the options represent alternative scenarios for native biodiversity management policy. Each option is described by a number of attributes describing native biodiversity quality outcomes across different landscape types. In each choice task, the combinations of attributes are systematically varied to denote different management options. Respondents are asked to choose the option with the combination of outcomes they prefer. We assume that the options chosen by respondents are what they think are best for them personally.

Statistical information derived from these choice tasks is econometrically modelled to quantify the relative importance of each biodiversity quality outcome. By including one key monetary attribute in choice tasks, the monetary value of other non-monetary attributes can be calculated. Economists express this as a willingness to pay (WTP), e.g. how much I am willing to pay to have a program that improves native biodiversity in marine environments. We use this value as the monetary estimate of the benefit of this management outcome.

2.2 Choice Experiment Survey Design

Exploring and finalising the choice of attributes that describe the outcomes of native biodiversity management was undertaken primarily with the expertise of staff at AERU and LandCare Research Ltd in conjunction with literature review findings and focus groups and cognitive interviews with the general public. The aim was to explore where changes in native biodiversity could occur, and how those changes could be characterised in the simple terms required for an online survey.

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[9] New Zealand Treasury. July 2015. Guide to Social Cost Benefit Analysis. Available at http://www.treasury.govt.nz/publications/guidance/planning/costbenefitanalysis/guide

2.2.1 Nonmarket valuation of native biodiversity in New Zealand

This section provides a summary review of published economic non-market valuation (NMV) of New Zealand biodiversity and is abbreviated from a more detailed examination of biodiversity valuation including methods and international application (see Miller et al., Forthcoming). The main objective of that report is to review non-market valuation literature deemed relevant to informing the development of a CE survey applied to value changes in New Zealand biodiversity. In doing so, the review aims to summarise existing studies to enable identification of knowledge gaps and methodological challenges. Biodiversity as a concept is problematic to define consistently, in this report we apply a broad frame of changes in the quality and quantity of native flora and fauna. A number of CE studies valuing biodiversity have been conducted in New Zealand, this review includes 14 CE studies and four other NMV applications conducted in the period 1995 to 2014 (Table 2.1).

Previous CE studies in New Zealand context have covered many specific locations and resources from coastal estuary and lake to natural parks and forests (in specific locations and nationwide) as well as private land (i.e. gardens). However, there have been a limited amount of nationwide studies. The studies have been dominated by a species framing while there is little comparison between ecosystem function (e.g. habitat) and species, and between different ecosystems. There are also only a few valuations comparing values for natives vs. non-natives, possibly due to the high significance of the native species in the unique environment. As biodiversity becomes more vulnerable, valuing of these different elements of biodiversity need exploration in order to extend the literature of NMV in New Zealand and internationally. Overall, studies were mainly site-specific with few applied to a national context directed to either the general public or farmers.

No NZ NMV studies have analysed public preferences for biodiversity outcomes across environment types such as, urban versus native forest.

A central objective in conducting the literature review of biodiversity valuation (Miller et al., Forthcoming) was to identify and construct a succinct list of lessons that could inform the development of the valuation exercise detailed in this report. Three critical challenges specific to designing a CE survey were derived from reviewing the literature that is addressed in our research design:

1. The first challenge concerns communication, how to convey biodiversity and its changes to the general public. In this:
    - Having more than one biodiversity attribute can help to capture the different elements of biodiversity and to avoid focussing bias or overestimation of the value of single species.
    - Visual cues are helpful in order to describe biodiversity outcomes
2. The second challenge is context dependency as resources can vary from good states of biodiversity to densely populated areas with limited quality outcomes. In this:
    - Providing a status quo alternative to respondents indicating current biodiversity outcomes gives context for respondent’s decision-making over changes, and practitioner analysis; avoids forced choices and increases realism; reveals protest votes and enables analysis of preferences for current outcomes.

- The selection of payment vehicle (e.g. taxes, rates or entrance fee) is important, can induce protest behaviour, and should reflect how potential users and non-users of the resource could actually pay for any changes in outcomes.

3. The third challenge includes considerations of who to survey and which survey mode to use.
   - In New Zealand, self-administered mail-and-return surveys have been the traditional mode, with online surveys becoming popular in recent years.
   - It is important to consider identification of respondents' spatial characteristics including home location and interaction with biodiversity outcomes valued in the CE.

Table 2.1: Summary of NZ biodiversity non-market valuation studies

Reference	Ecosystem	Pop. Sample	Biodiversity Location	Biodiversity Outcomes
Kerr and Sharp (2007)	Tussocks	Twizel Timaru Fairlie Christchurch	Mackenzie Basin	Wilding Pines Hebe cupressoides Robust grasshopper *Bignose galaxias* (fish)
Bell (2008)	Estuary	Wellington	Pauatahanui Inlet	Shellfish take Estuarine vegetation Shellfish decline Children paddling
Kerr and Sharp (2008a)	Beech forest	Nelson Christchurch	Nelson Lakes Beech forest	Wasp sting probability Amount of birds Amount of insects
Ker and Sharp (2008b)	Streams	Auckland	Urban streams, Auckland	Water clarity Native fish species Fish habitat Native vegetation Channel form
Yao and Kaval (2009)	Trees	National	National	Natives and non-natives
Baskaran et al. (2009)	Pastoral agriculture	Canterbury	Canterbury	Methane gas emissions Nitrate leaching Water use for irrigation Scenic views
Bell et al. (2009)	Lake	Rotoroa Hamilton Morrinsville Karori	Lake Rotoroa	Preventing hydrilla cover Preserving charophytes cover Shag species Fish species and mussels Water quality
Baskaran et al. (2013)	Tussock/Pastoral	Otago Canterbury	Mackenzie Basin	Conservation land Landscape scenery, pastoral Biodiversity loss Surface water quality Jobs
Lee et al. (2013)	Native forest/coastal	Visitors	Abel Tasman National Park	Native Bird Species Onsite Information Accommodation facilities Number of Visitors
Piddock (2014)	Agricultural	Waikato	Waikato	Habitat management Locally important species Ecosystem Services
Yao et al. (2014)	Plantation forest	National	National	Brown Kiwi Giant Kokopu Kakabeak shrubs Green Gecko Bush Falcon
Tait et al. (2014a)	Agricultural	National	National	TB infection rate Possum damage on farm Presence of possums on farm Possum threat to natives
Tait et al. (2014b)	Native forest	National	National	Canopy tree species Large native invertebrates Native birds Within-forest plants

2.2.2 Expert workshops

Workshops were conducted with AERU and LCR staff to explore the appropriate research design relevant to an objective of measuring public values for native biodiversity outcomes. The workshops acted primarily as a conduit for coalescing diverse viewpoints concerning native biodiversity management inherent across different scientific disciplines. An iterative dialogue emerged whereby the AERU team led discussion presenting NMV method and explored how relevant economic method could appropriately be applied to biodiversity assessment, and the LCR team led a discussion on diverse biophysical aspects of native biodiversity management and outcomes. This process created a representation of the current state of native biodiversity management approaches, outcomes, and tensions, which was able to be responded to in proposing research design. In this way, the expectation was to develop an interdisciplinary approach to evaluate native biodiversity management outcomes by combining economic and biological measures of value to form an assessment of biodiversity outcomes that integrated natural and social science perspectives.

Workshop discussion themes included:

- Current and emerging native biodiversity threats and management limitations
- Explore strategic areas of possible science effort application that could suitably be explored using a survey of NZ general public
- Determine research questions relevant to native biodiversity that could be explored within the NMV CE survey of NZ public.
- Shifts in management target towards e.g. farmed landscapes
- Management effort in current conservation areas versus improving urban native biodiversity
- Introduction and discussion of NMV method focusing on the CE approach
- What CE design approaches might be suited to informing biodiversity management decisions
- The need for information indicating public preferences for biodiversity outcomes across a broad set of NZ environments
- How native biodiversity management could be implemented
- Which factors are important to consider in choice to conduct biodiversity management
- Do public view biodiversity as providing public or private benefits
- Do people only support improving biodiversity outcomes that are located relevant to them
- Location/spatial behavioural effects on public preferences
- Provide implications for policy development signalling priorities for management effort

A key outcome from the workshops informing CE research design was the determination that a high-level assessment of public preferences for native biodiversity outcomes across different environments could inform decisions concerning appropriate focus of science effort and resources.

2.2.3 Public focus groups

The purpose of conducting focus groups was to acquire information on the knowledge and experience, perceptions, and preferences of the NZ public about the state of native biodiversity, and its protection and enhancement in NZ, which could inform the design of the CE survey of NZ residents.

Two focus groups were held in August 2014 near Christchurch. This section summarises the full focus group report (available on request). One of the discussions was held at Lincoln University in Lincoln, a rural township approximately 20 kilometres from Christchurch. Lincoln is home to a number of Crown Research Institutes and Lincoln University, and the township has a strong and well-publicised environmental trust. The second group was held at Kirkwood Intermediate in Riccarton, a suburb close to the centre of the city with a diverse population and business base.

The members of both groups had an interest in biodiversity and considered biodiversity protection and enhancement as important for a range of reasons including the health of the environment and communities; cultural identity; the tourism industry; and New Zealand's image in international markets. This is perhaps not surprising since it is unlikely that people with no interest in the subject could be persuaded to attend a meeting of this sort. However, all members of both groups believe that awareness of the importance of biodiversity and its linkages with environmental health is diminishing in the wider community, and regarded this as a matter of concern. They all considered that the state of New Zealand's biodiversity is deteriorating, that not enough is being done to protect and enhance it for the benefit of future generations, and that intervention is urgently required.

Group participants defined biodiversity in terms of ecological balance and the "natural order", rather than in terms of species richness and abundance only. A number of threats to biodiversity were defined. The most significant threats identified were the dairy industry (Lincoln group) and increasing urbanisation (Kirkwood group).

The key to improving biodiversity in New Zealand was considered by both focus groups to be increased environmental education in schools. It was considered that a generation is growing up of which a large proportion have no familiarity or connection with the natural environment and no understanding of its importance in our day-to-day existence.

Although both groups regarded the restoration of ecosystem balance to be the best avenue to protecting and enhancing biodiversity, they identified different approaches to achieving this. The Lincoln group believed balance to be largely achievable by means of restoring soil and water health, which will lead naturally to the reestablishment of native flora followed by other species; and by the identification and protection of representative ecosystems. The Kirkwood group favoured the establishment of a network of native reserves, and the protection of priority native species until the balance has been restored sufficiently to sustain them.

The groups differed in their views on whether publicly funded biodiversity protection should be limited to the protection of native species, with the Kirkwood group favouring the protection of native species only and the Lincoln group believing that some valuable introduced species warrant protection.

The Lincoln group had strong views on the processes for deciding on biodiversity protection priorities. They felt that the process should be led by government agencies and universities and decisions made by experts from diverse disciplines. A transparent, robust scoring system should be developed that incorporates all the values of an ecosystem and its components.

Public/private partnerships should be part of a mainstream strategy for biodiversity protection, but only if private interests do not over-ride biodiversity values when determining the best outcomes and most appropriate approaches.

Three central implications for the CE survey design extrapolated from focus groups were:

- A habitats based approach to native biodiversity conservation is preferred over a species-specific type approach.
- Different approaches to how biodiversity management is implemented are important to consider.
- Differing considerations in determining native biodiversity management priorities are important to consider.

2.2.4 Attributes and Levels

Synthesizing literature review, workshop and focus group findings led to the development of a habitats focused framework for assessing public preferences for native biodiversity outcomes in the CE design. An assessment of public preferences for native biodiversity outcomes using a habitats framework is consistent with the ecological perspective that habitat loss makes biodiversity more irreplaceable and more vulnerable to future loss. The principle of protecting habitat rather than specific species aligns with a fundamental relationship in ecology-the species-area relationship; which indicates that the risk to biodiversity increases more rapidly as habitat loss advances. This means that as habitat loss advances, each additional increment of habitat loss will remove a larger proportion of the original species that it once contained.

Five environment types where native biodiversity outcomes could be realised were identified as the 'outcome attributes' of native biodiversity management that would be relevant in the context of a national level survey. These are:

1. **Native Forest Environments**

   Covering over a third of NZ, native forests provide many economic, recreational and cultural benefits. They are particularly important for native conservation because they support a large amount of habitat for native plants and animals that have been only moderately affected by humans. Pests such as possums pose major threats to native forests. Approximately 69 per cent of NZ's native forest is currently under management (e.g. possum control) that provides native biodiversity benefits.

2. **Marine Environments**

   NZ's marine environment stretches from our beaches to kilometres offshore. As much as 80 per cent of NZ biodiversity may be found in our marine environment providing significant economic, recreational and cultural benefits to society. Impacted by humans through resource harvesting, land-based sources of pollution, and the introduction of marine pests, management approaches (e.g. restricted fishing) include Marine Reserves. To date, we have 44 marine reserves covering approximately 1 per cent of our marine environment.

3. **Farmed Landscape Environments**

   Much of NZ's natural landscape has been developed for agricultural and forestry activities. These environments are still capable of providing important habitats for native biodiversity. For example, plantation forestry and rough farmland provide habitats for the endangered Brown Kiwi. On-farm planting of wildlife corridors connecting habitat and wildlife populations, and fencing off stock animals from remnant native forest, both support native species. Approximately 4 per cent of NZ's farmed landscape is under management (e.g. planting natives) that provides native biodiversity benefits.

4. **Lowland Freshwater Environments**

   NZ lowland freshwater habitats including rivers, lakes and wetlands are home to a wide variety of native plants and animals providing economic, recreational and cultural benefits. They are subject to significant pressures from modification and drainage, pollution and sedimentation, nutrient enrichment, abstraction, and invasion by pests. These impacts have had significant consequences for our vulnerable lowland freshwater biodiversity. Approximately 38 per cent of NZ has management (e.g. fencing off waterways) in place providing biodiversity benefits in lowland freshwater habitats.

5. **Urban Environments**

   Urban native biodiversity, including urban forests, parks, reserves and household backyards are recognised as providing multiple benefits to communities including amenity, cultural and recreational. Urban environments pose many threats to native biodiversity including loss of habitat, predation of birds, and pollution. Approximately 7 per cent of urban environments in NZ has environmental management (e.g. re-vegetation and urban possum control) in place providing native biodiversity benefits.

Using written and pictorial depiction, the outcomes for each native biodiversity habitat are described by three levels: poor, moderate and good (Table 2). The development and testing of descriptions were conducted using cognitive interviews as detailed below.

2.2.5 Experimental Design

In practice, it is not possible to present respondents with all possible combinations of attribute levels (Table 2). Instead, Experimental Design methodology is used to create combinations of attribute levels, which represent a subset of the total combinations possible, and maximise the amount of statistical information available. These combinations are formed into choice sets. Figure 2 presents an example of a choice set shown to respondents. Each choice set comprises three options, of which respondents chose their preferred option. The first option is a 'current biodiversity management' option that represents a scenario in which native biodiversity policy is not expanded from current levels, and therefore no additional cost is imposed on respondents. This option is the same for all choice sets that a respondent sees, and is known as the constant base that respondents compare other options against. The other two options represent scenarios in which native biodiversity policy is expanded, and contain improvements in native biodiversity outcomes for each attribute compared to the constant base option. These two management change options do impose an additional annual cost on respondents.

The study employs NGene[10] software to apply a D-efficient fractional factorial design approach[11]. Providing information on the likely values of model coefficient estimates improves this process. For the initial experimental design, we looked at similar studies for design parameters, then updated these with

[10] ChoiceMetrics (2014) Ngene 1.1.2 User Manual & Reference Guide, Australia.

[11] Cook RD. Nachtsheim CJ. 1980. A comparison of algorithms for constructing exact D-optimal designs. Techometrics 22:315-324.

coefficient estimates from a model fitted to pilot survey data (n=100). The resulting updated experimental design is applied to the remaining number of respondents with each respondent answering six choice sets.

Table 2.2: Attribute descriptions and levels for choice tasks

ve Biodiversity Habitats	Biodiversity Outcomes Poor	Moderate	Good
Marine	 Declining health of ecosystem. Biological diversity is low. Large drop in species numbers.	 Stable health of ecosystem. Moderate level of biological diversity. Some drop in species numbers	 Improved health of ecosystem. Original number and variety of species present.
Native Forest	 Heavy browse and dieback of vulnerable canopy species. Most within-forest plants heavily defoliated.	 Many forests with healthy unbrowsed tress. Some but not all vulnerable within-forest plants protected.	 Majority of forest with healthy unbrowsed trees. Majority of forest with healthy within-forest plants.
Farmed Landscape	 Few farm margins planted with natives. Little fencing off of remnant native forest. Few wildlife corridors planted.	 Moderate amount of farm margins planted with natives. Some fencing off of remnant native forest. Some wildlife corridors planted.	 Most farm margins planted with natives. Extensive fencing off of remnant native forest. Extensive planting of wildlife corridors.
Urban	 Few private gardens contain native plants. Few public parks contain range of native plants. No restoration of degraded natural features. Street verges planted with exotics	 Some private gardens contain native plants. Some public parks contain range of native plants. Some restoration of degraded natural features. Street verges planted with natives and exotics.	 Most private gardens contain native plants. Most public parks contain range of native plants. Substantial restoration of degraded natural features. Street verges planted mostly with natives.
Lowland Freshwater	 Little riparian planting. High level of pollution from a variety of sources. Number and diversity of species declining.	 Some riparian planting. Moderate water quality. Moderate number and diversity of species.	 Waterway in near-natural state. Clean un-enriched water with minimal algae. High level of species diversity and numbers.

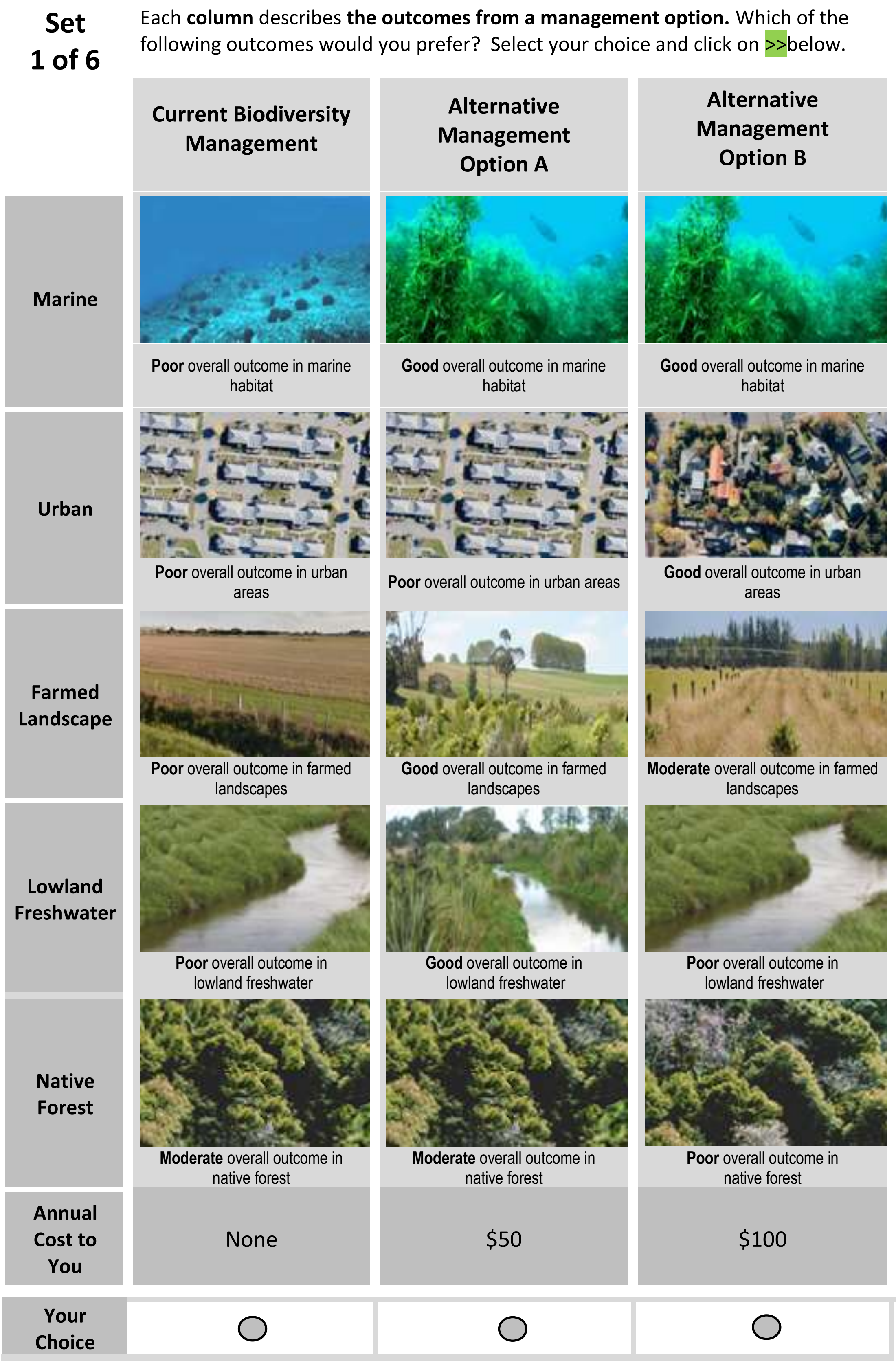


Figure 2.1. Example choice set presented to respondents

2.2.6 Cognitive Interviews

Cognitive Interviews are a leading methodology for testing questionnaires during design and implementation phases. The central aim is an assessment of whether respondents comprehend questions as intended by the researcher and whether questions can be answered accurately[12]. The method involves respondents being prompted individually to respond to a questionnaire by an interviewer who asks them to think aloud as they go through the survey and tell the interviewer what is being thought about the questions and how answers are being formed. The interviewer probes in order to explore issues including interpretation of questions.

We employed Cognitive interviews to obtain feedback on draft questionnaires from a number of people, including those with specialised knowledge of some aspect of questionnaire quality, particularly regarding CE design elements, and end-user usability of the online mode format being used. We also conducted Cognitive interviews with the complete questionnaire in order to identify wording, question order, visual design, and navigation problems. We conducted five interviews across a mix of gender, age and occupation, each with duration of 1.5 to 2.5 hours.

2.2.7 Survey Administration

We obtained a sample of New Zealand resident respondents from Research Now (researchnow.com), a research consultancy that provides analytical services and maintains one of the largest global databases of survey respondents. Their panel of members are paid for completed surveys. This sampling method allowed for the pre-stratification of the sample by age, gender, income, and regional location. Prior to the full launch of the survey instrument, we conducted a pilot study with a subsample of the population (n=100) in order to evaluate interconnections among questions, the questionnaire, and the implementation procedure.

We conducted an internet survey of a sample of New Zealand residents in November 2015 using names and contact details obtained from a database maintained by Research Now. The final sample consisted of 985 residents from throughout New Zealand. The survey was administered using an online survey mode employing Qualtrics™ online survey software, and proprietary software for implementing CE surveys maintained by AERU. The process consisted of contact through an email invitation to New Zealand residents that contained a link to the online survey.

[12] Dillman DA. et al. 2009. Internet, Mail, and Mixed-Mode Surveys: The Tailored Design Method. -3rd ed. John Wiley & Sons Inc., Hoboken, New Jersey.

Chapter 3
Results

3.1 Sample Characteristics

A total of 985 New Zealand residents provided responses to the survey. Table 3 describes the composition of the sample by various demographic variables, including location. To determine whether the sample is representative of the general NZ population, we statistically tested that the distribution of the observed sample demographics was consistent with that of the general population, as provided by Statistics NZ 2013 data. Table 3 indicates that the sample composition was overall a good representation of the NZ population, with only education skewed towards higher levels relative to that of the general population.

To capture information indicating the level of environmental consciousness among survey respondents they were asked which activities they participated in that they consider support native biodiversity (Fig.3). The observed high level of recycling and composting is perhaps to be expected, given that recycling is a municipal service and can be considered a social norm.

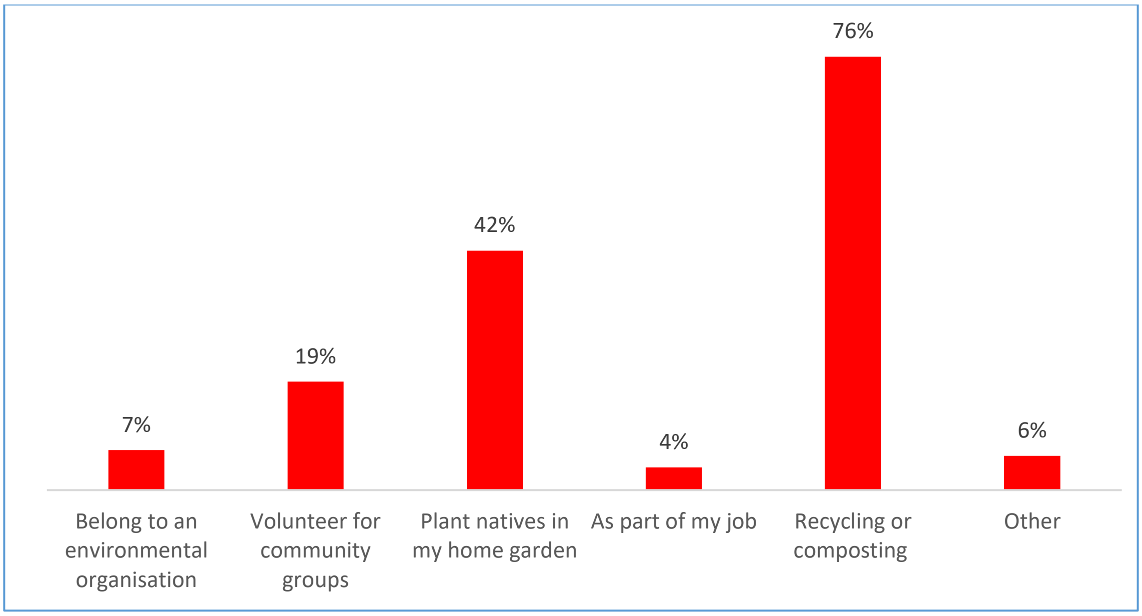


Figure 3.1. Respondent's personal activities supporting native biodiversity outcomes

Table 3.1: Sample characteristics

Demographic Variable		Sample Distribution (per cent)	NZ Population Distribution (per cent)[1]
Age [p = 0.95][2]	65 years or more	20	19
	55 – 64 years	16	15
	45 – 54 years	19	19
	35 – 44 years	16	18
	25 – 34 years	17	16
	18 – 24 years	12	13
Gender [p = 0.69]	Female	53	51
Education [p = 0.00]	High school	25	50
	Trade/technical qualification or similar	19	9
	Undergraduate diploma/certificate/degree	31	14
	Postgraduate degree	21	6
	None	4	21
Occupation[3] [p = 0.58]	Unemployed	4	4
	Retired	10	14
	Unpaid voluntary work	2	1
	Student	9	6
	Paid employment	64	65
	Home duties	9	8
Personal Income [p = 0.93]	Loss	1	1
	$0 - $20,000	30	38
	$20,001 - $40,000	27	26
	$40,001 - $50,000	12	10
	$50,001 - $70,000	15	13
	$70,001 - $100,000	9	8
	$100,001 or more	6	6
Household Size [p = 0.69]	One	17	22
	Two	36	34
	Three	18	17
	Four or more	29	27
Region [p = 0.95]	Auckland	23	33
	Bay of Plenty	6	6
	Canterbury	13	13
	Gisborne	1	1
	Hawke's Bay	5	4
	Manawatu-Wanganui	6	5
	Marlborough	2	1
	Nelson	2	1
	Northland	4	4
	Otago	5	5
	Southland	3	2
	Taranaki	4	3
	Tasman	1	1
	Waikato	10	10
	Wellington	13	11
	West Coast	2	1

[1] Distributions from Statistics NZ Census 2013. [2] Values in brackets are p-values for Pearson's Chi-squared test of the null hypothesis that the frequency distribution of the observed sample demographic variable is consistent with the population distribution provided by Statistics NZ Census 2013 data. A p-value less than 0.1 indicates a statistically significant difference between the distributions; p-values greater than 0.1 indicate that the demographic distribution is not statistical different to the population and therefore are representative of the general population. [3] Population distributions from 2013 Household Labour Force Survey.

3.2 Native biodiversity perceptions, attitudes and experiences

Differing perceptions, attitudes, and experiences of survey respondents in relation to native biodiversity can influence their preferences for how these resources are managed, and for different types of native biodiversity quality outcomes. The survey began by asking respondents a series of questions focused on these three elements. These questions also provide context and framing that enables respondents to think about and recall what benefits they derive from biodiversity quality outcomes across different environments.

3.2.1 Perceived quality of native biodiversity

Preferences for native biodiversity management efforts may be influenced by respondents' desire to address areas of greatest need. Respondents were asked to describe what they thought was the overall quality of native biodiversity in different types of environments in New Zealand, on a scale of: very high, good, satisfactory, poor, or very low (Fig. 4).

- The greatest levels of perceived quality are for native forests, with 69 per cent of respondents believing native forest environments to be good or very high quality. Native forests also have the lowest levels of dissatisfaction, with 9 per cent believing native forest biodiversity habitats to be poor or very low quality.

- Urban environments are perceived to be the worst quality with 35 per cent of respondents believing urban native biodiversity habitats to be poor or very low quality and 21 per cent believing urban native biodiversity habitats to good or very high quality.

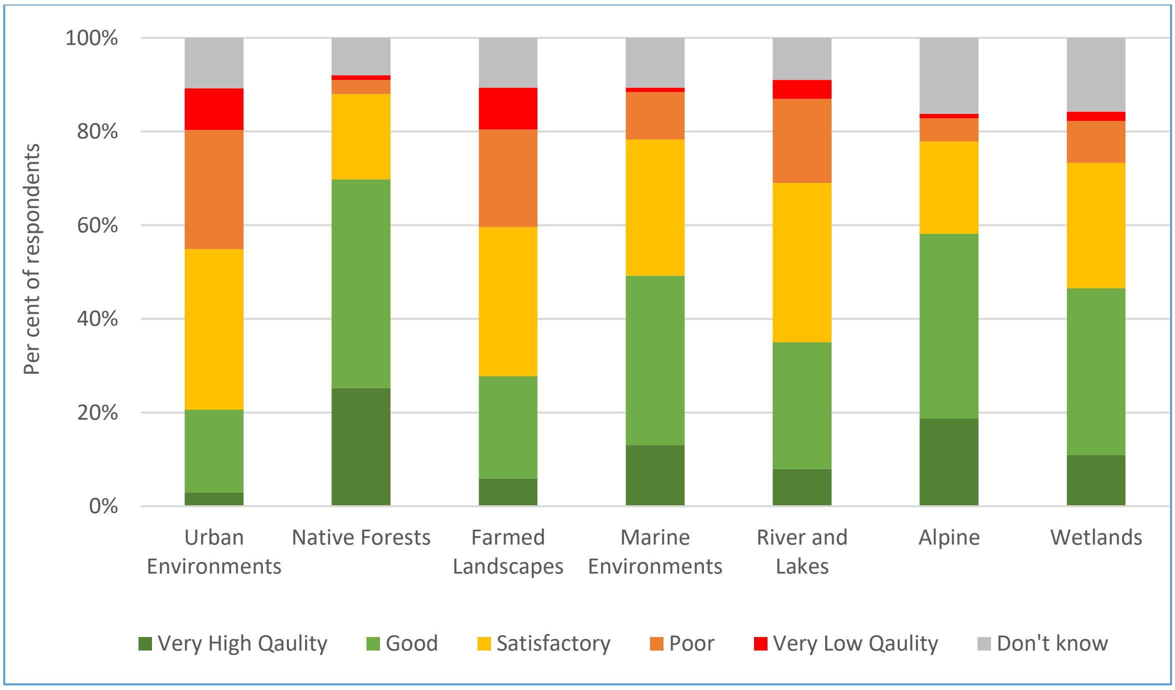


Figure 3.2. Respondent perceptions of overall quality of native biodiversity environments

3.2.2 Attitudes towards native biodiversity management

There can be many factors that managers are required to take into account when determining the level of management effort devoted across biodiversity programs. To gauge which factors the public consider to be important, we asked respondents to indicate which factors they thought native biodiversity managers should consider when allocating resources across biodiversity programs on a scale of: very important factor to consider, significant consideration, neither, minor consideration, do not need to consider (Fig. 5).

- The most important factor to consider is whether biodiversity is endangered, with 87 per cent of respondents believing protecting endangered biodiversity is a significant or very important factor to consider. Whether biodiversity was endangered also had the lowest levels of non-consideration, with 1 per cent believing endangerment to be a minor consideration.
- Respondents indicated that cultural significance was the least important factor to consider with 9 per cent of respondents believing it a minor factor or one that doesn't need considering.

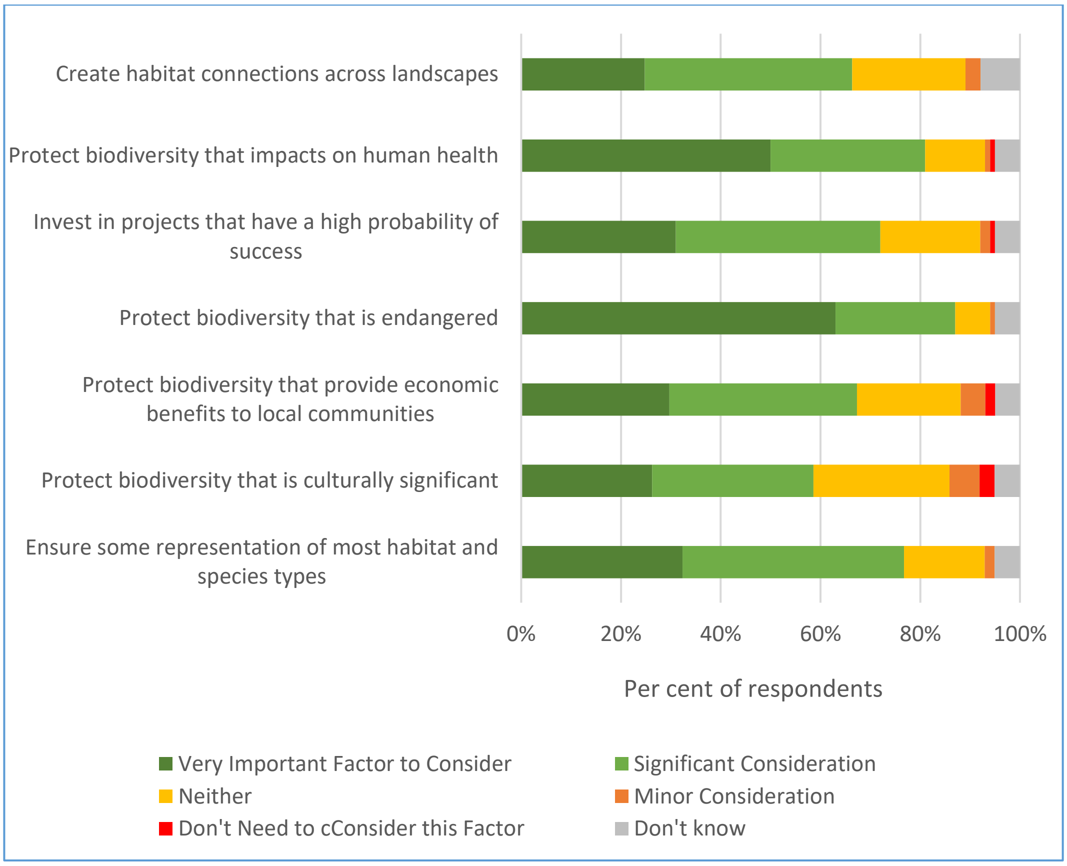


Figure 3.3. Public perceived importance of management factors

Numerous biodiversity management tools and approaches are adopted in New Zealand. To gauge public support for various approaches, we asked respondents to indicate their level of agreement with statements describing management approaches on a scale of: strongly agree, agree, neither, disagree, and strongly disagree (Fig. 6).

- The strongest level of support was found for polluter-pays approaches; with 83 per cent of respondents agreeing or strongly agreeing that stronger rules should be made into law to help change biodiversity damaging behaviour from polluting industries. This approach also had the lowest levels of disagreement; with 2 per cent of respondents disagreeing with stronger rules.
- The lowest level of support was found for border tax approaches; with 44 per cent of respondents agreeing or strongly agreeing that international tourists should pay a levy that would contribute to biodiversity management. This approach also had the highest levels of disagreement; with 21 per cent of respondents disagreeing or strongly disagreeing with tourist levies.

Figure 3.4. Publics' support for biodiversity management approaches

3.2.3 Engagement with biodiversity habitats

Respondent's preferences for the changes in native biodiversity outcomes in the environments used in this study – urban, farmed landscape, marine, native forest and lowland freshwater – are likely to be influenced by the amount of contact with each of these environments they have. To capture this potential source of preference differences, respondents were presented with a series of questions exploring the range of activities undertaken by them the last 12 months. For each activity, they were asked to locate on a map of NZ the location where they most frequently engaged in a series of activities, and how many times had they visited this location to engage in the activity in the previous 12 months.

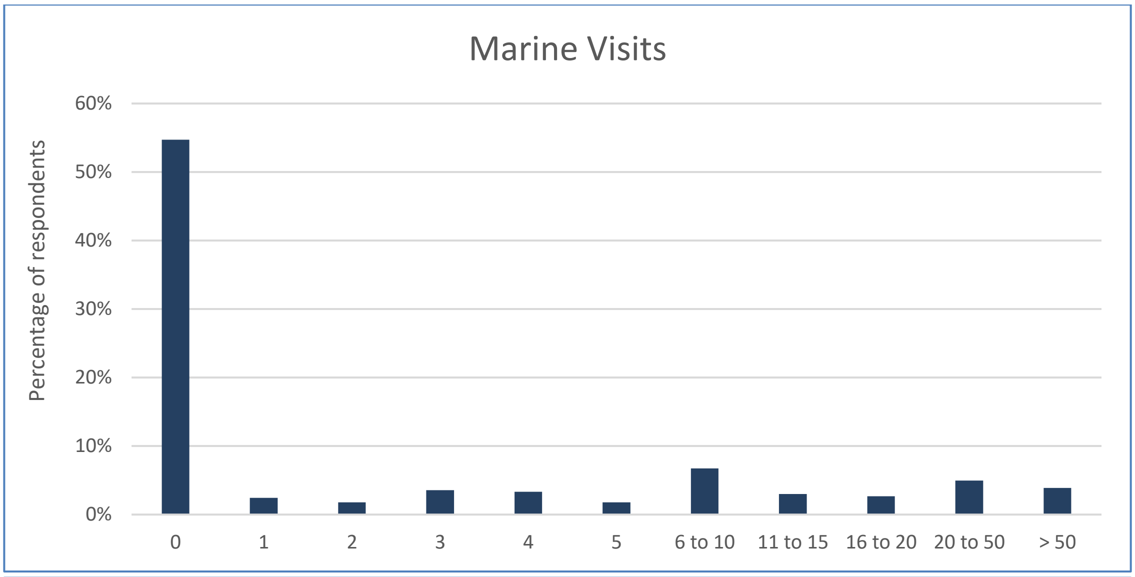
Using a GIS approach, the coordinates of each respondent's activities were analysed in relation to LCDB v4.1[13] to determine the types of environments in which respondents engage with. The objective is to create environment type variables that align with the environments in which native biodiversity outcomes could be improved as used in the CE presented to them. The distribution of LCDB class groupings (Appendix B) into the four environment definitions (marine environments are not included in LCDB) shows that farmed landscapes are the predominant land cover (Table 4). To construct the lowland freshwater variable we use the New Zealand Mainland Contours (Topo 1:250k)[14] dataset to exclude waterways above 1,500m in the South Island and 900m in the North Island. The Land Cover Database is created from satellite images and has been updated several times to improve classifications. While there may be some inaccuracies, in aggregate the effect of this will be small. Our use of the classifications has not been exhaustive but has been attempted to best align the LCDB v4.1 classifications with the environments examined.

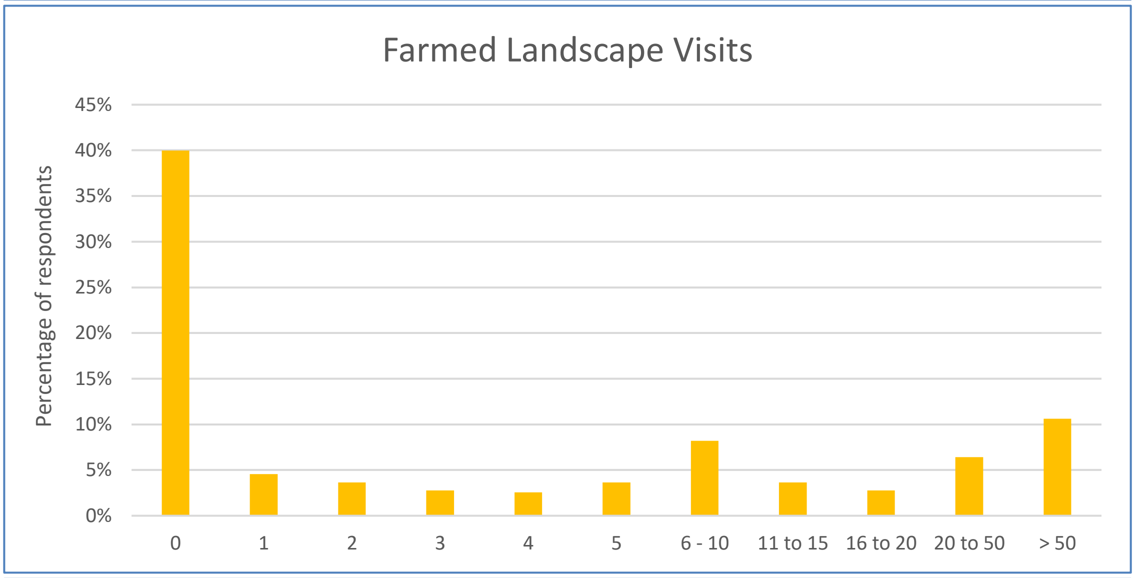
Table 3.2: Environment type definitions applied to LCDB

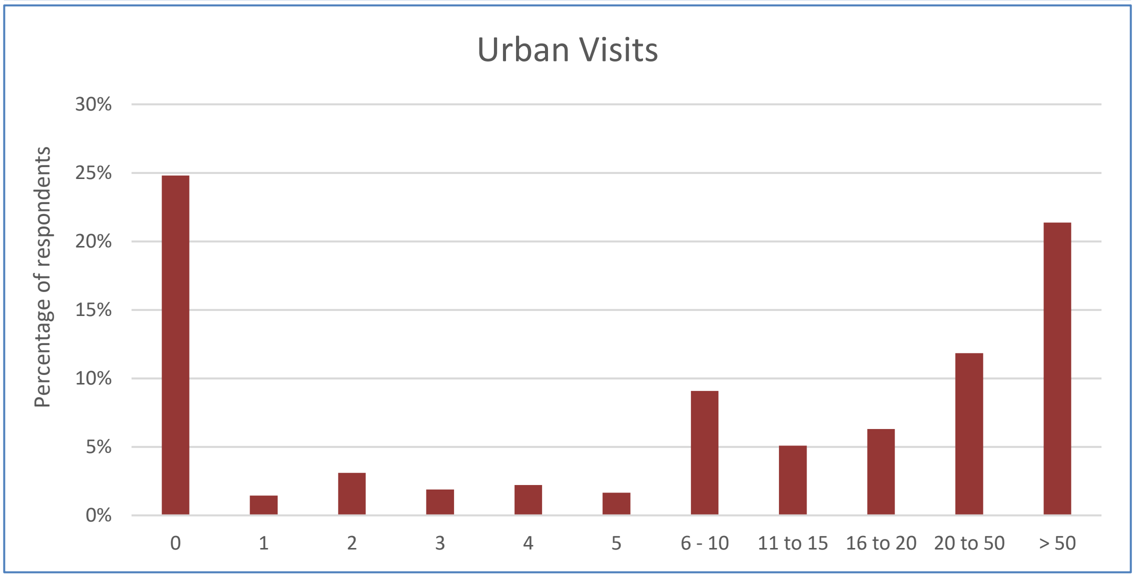
Environment Classifications	Distribution across LCDB (per cent)
Native Forest	30
Farmed Landscapes	49
Lowland Freshwater	2
Urban	1
Undefined	17

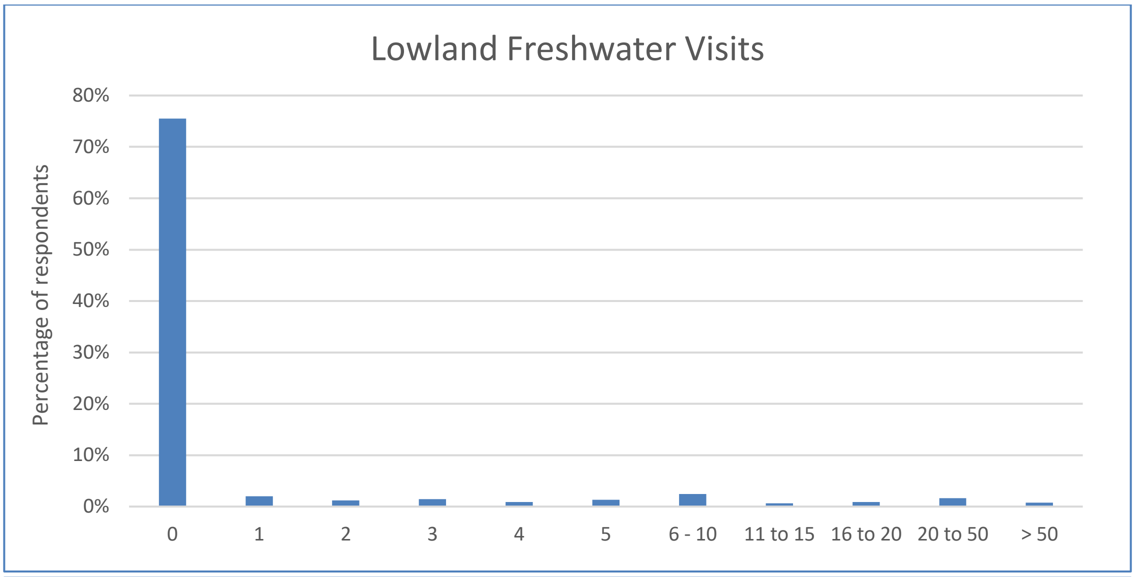
Respondents were most likely to have engaged in an activity in an urban setting in the last 12 months (75 per cent) followed by farmed landscapes (60 per cent), just as likely to visit marine (45 per cent) or native environments (43 per cent) and were less likely to have visited lowland freshwater environments (25 per cent) (Fig. 7). Examining visit frequency reveals that a proportion of the sample have a relatively high frequency of use. This group is categorized into respondents who make 50 or more visits in the last 12 months and this is the most common visit frequency for those engaging in activities in urban, or farmed landscape environments. Interestingly, the most common visit frequently to marine, native, or lowland freshwater environments is 6 to 10 times in the last 12 months.

[13] https://lris.scinfo.org.nz/layer/423-lcdb-v41-land-cover-database-version-41-mainland-new-zealand/
[14] https://data.linz.govt.nz/layer/159-nz-contours-topo-1250k/


Marine Visits
Percentage of respondents
60%
50%
40%
30%
20%
10%
0%
0
1
2
3
4
5
6 to 10
11 to 15
16 to 20
20 to 50
> 50


Farmed Landscape Visits
Percentage of respondents
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
0
1
2
3
4
5
6 - 10
11 to 15
16 to 20
20 to 50
> 50


Urban Visits
Percentage of respondents
30%
25%
20%
15%
10%
5%
0%
0
1
2
3
4
5
6 - 10
11 to 15
16 to 20
20 to 50
> 50



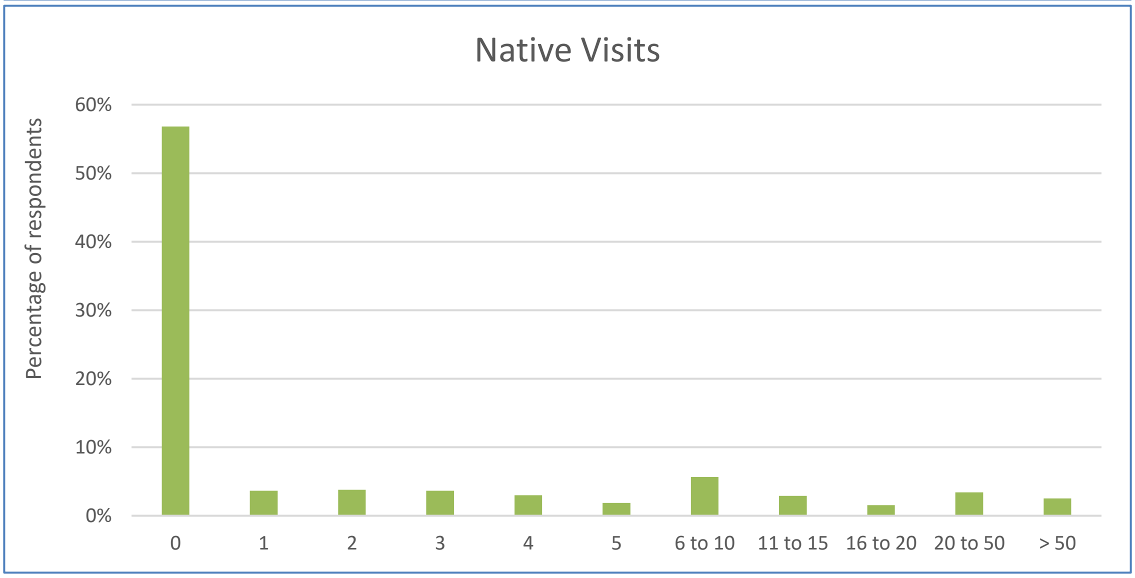
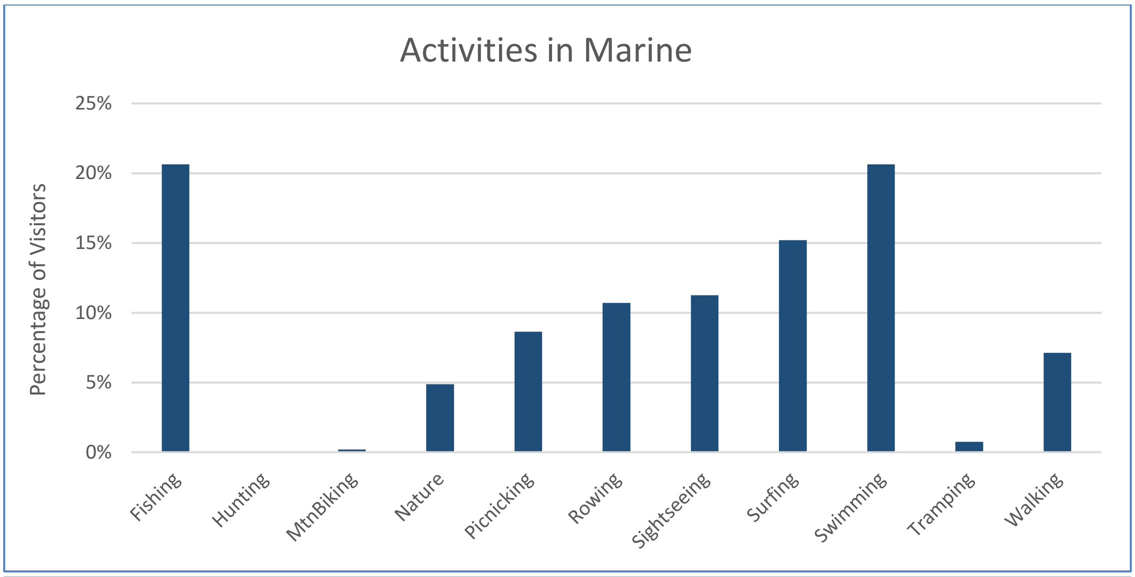


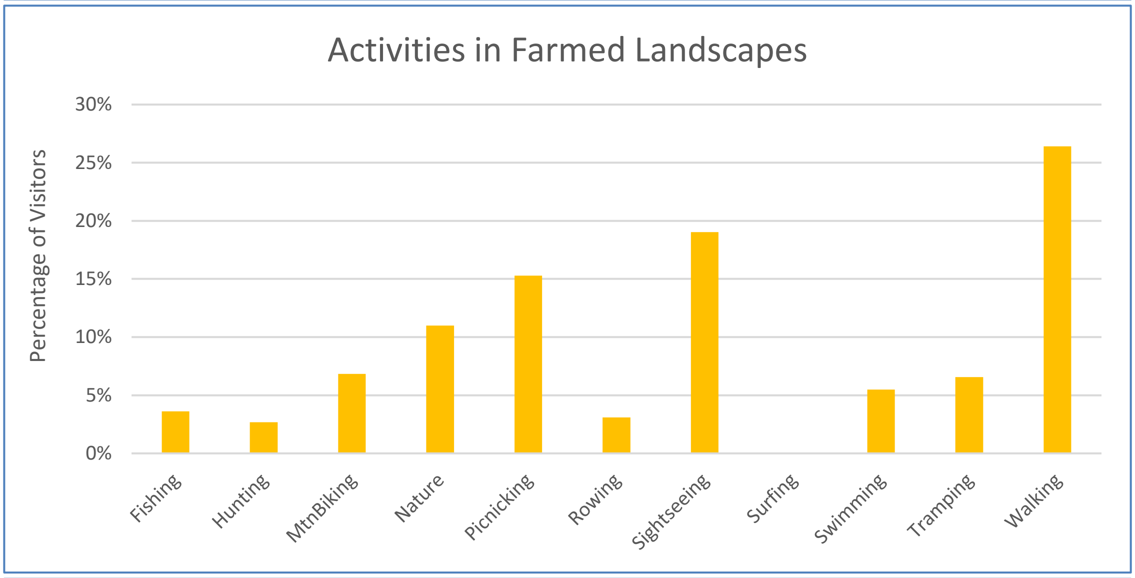
Figure 3.5: Distribution of number of visits to environments in the last 12 months

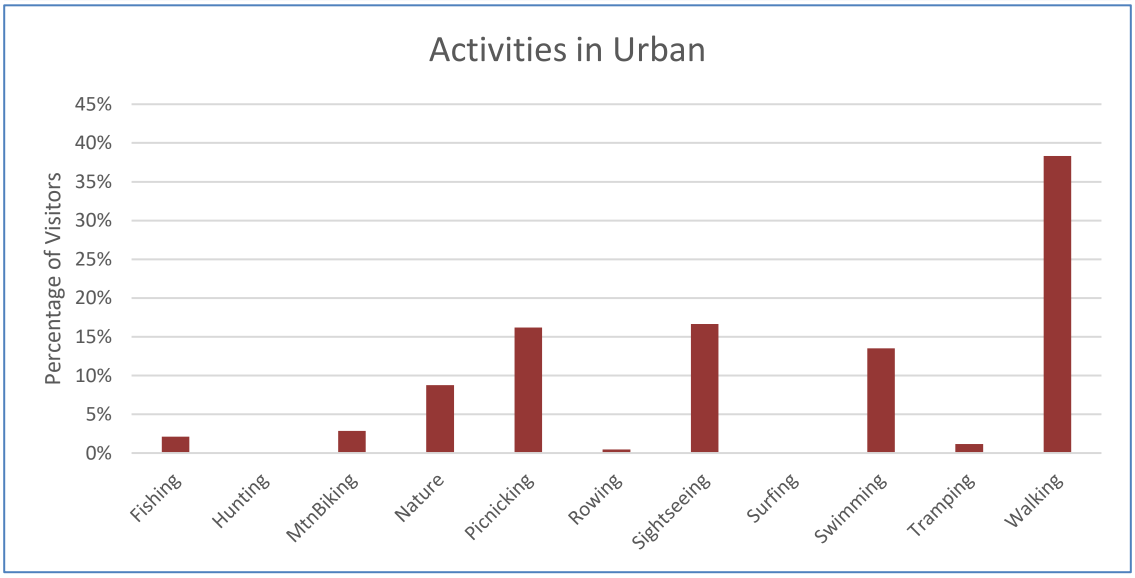
The types of activities that respondents participated in across environment types are shown in Figure 8. The key results for this question were as follows:

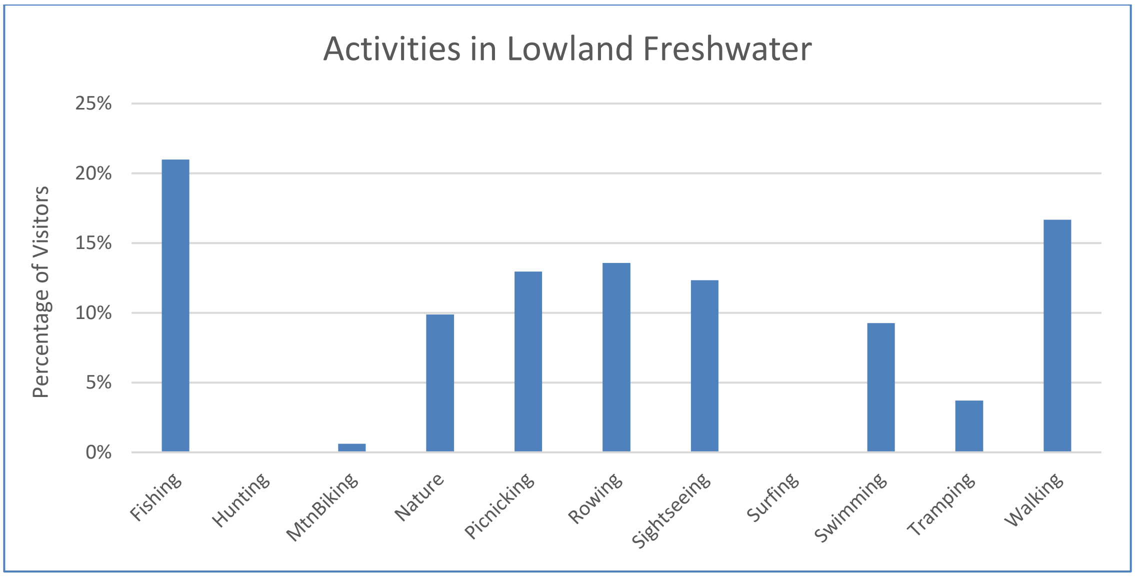
- **Marine** The highest number of visitors to marine environments went there for fishing (21 per cent) and swimming (21 per cent), followed by surfing (15 per cent).
- **Farmed** The highest number of visitors to farmed landscapes went there for walking, running or jogging (26 per cent), followed by sightseeing (19 per cent) and then picnicking (15 per cent).
- **Urban** Similarly, visitors to urban environments most often went there for walking, running or jogging (38 per cent) followed by sightseeing (17 per cent) and picnicking (16 per cent).
- **Freshwater** The highest number of visitors to lowland freshwater environments went there for fishing (21 per cent) followed by walking, running or jogging (17 per cent) and then rowing, kayaking and canoeing (15 per cent).

- **Native** Most visitors to native environments went there to experience nature (18 per cent) or for sightseeing (18 per cent), followed by tramping (17 per cent).









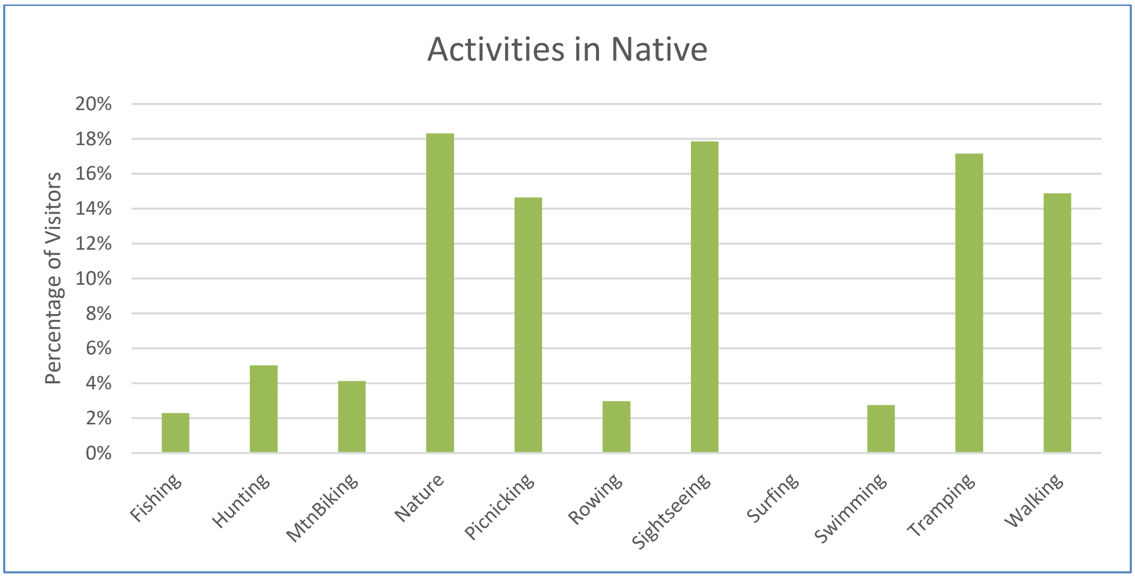


Figure 3.6. Respondent involvement in activities at environments in last 12 months

We calculated the distance traveled between a respondent's resident location and the environment type location where an activity was conducted. Figure 9 shows the average number of visits to the five environment types in the last twelve months overall respondents, alongside the average distance travelled per visit. This shows that the highest average level of engagement, by a considerable margin, is with urban environments (46 visits) followed by farmed landscapes (25 visits) and marine (10 visits). Average distance travelled to marine environments is the highest (23km) with farmed landscapes (6km) and urban environments (4km) exhibiting considerably shorter travel distances.

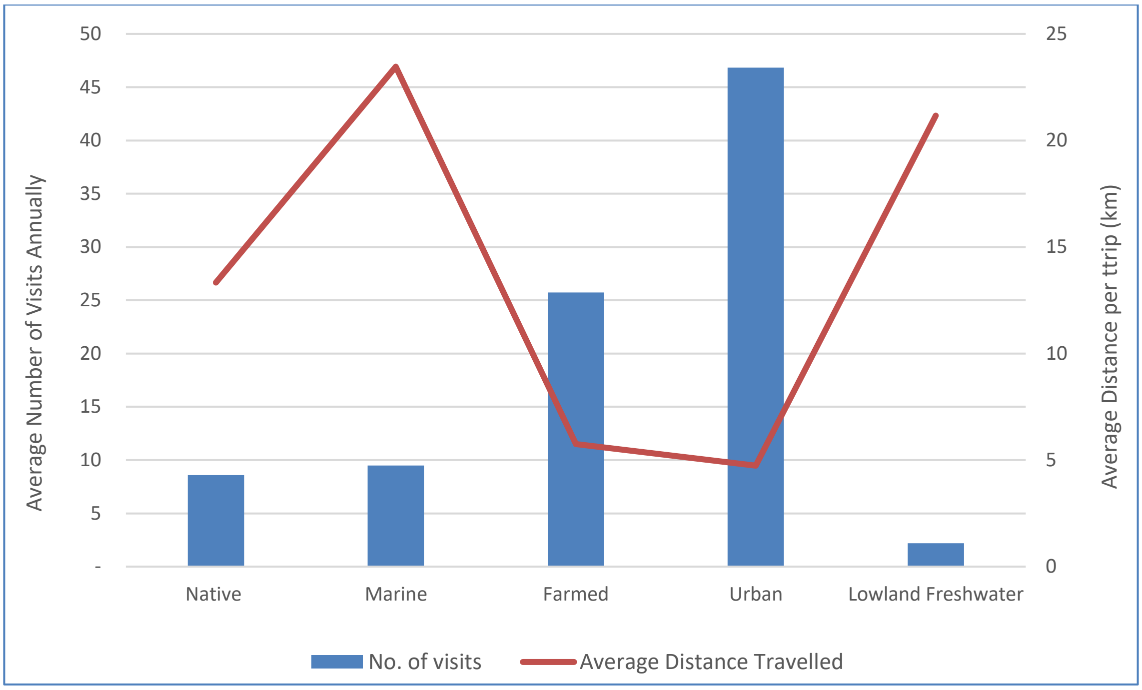
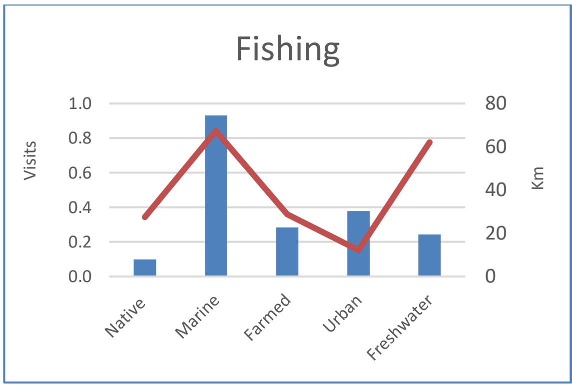


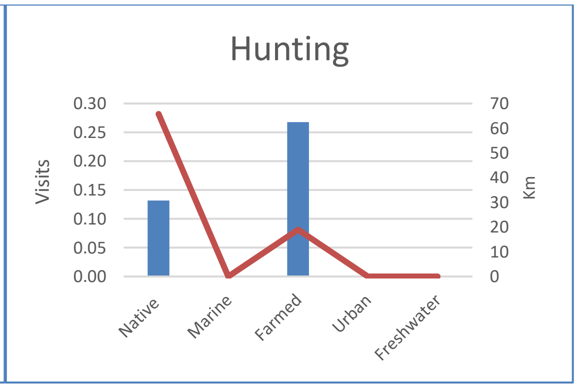
Figure 3.7: Respondents' Average number of visits and distance traveled to environments in the last 12 months.

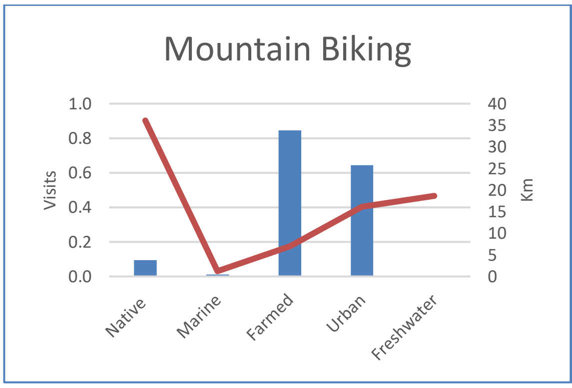
Examining average trip frequency and distances travelled over all respondents by recreational activity (Fig. 10) shows that visitors most frequently engage with:

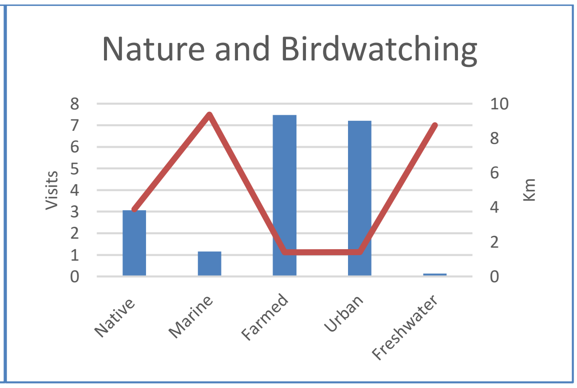
- Native environments for walking/running/jogging, followed by nature/ bird watching.
- Marine environments for walking/running/jogging, followed by swimming.
- Farmed landscape environments for walking/running/jogging, followed by nature/ bird watching.
- Urban environments for walking/running/jogging, followed by nature/ bird watching.
- Lowland freshwater environments for walking/running/jogging, followed by sightseeing.

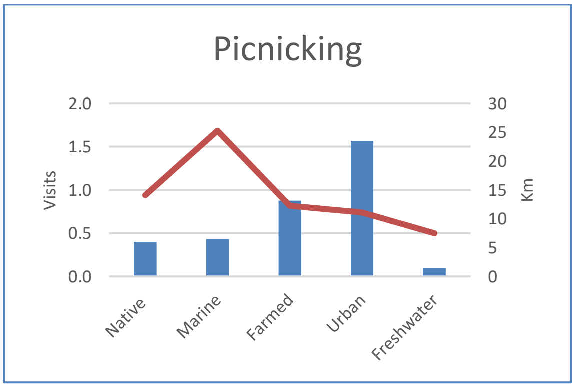
The furthest distances travelled on average were for swimming in native forest and the closest distances traveled, across all environments, was for walking/running/jogging.

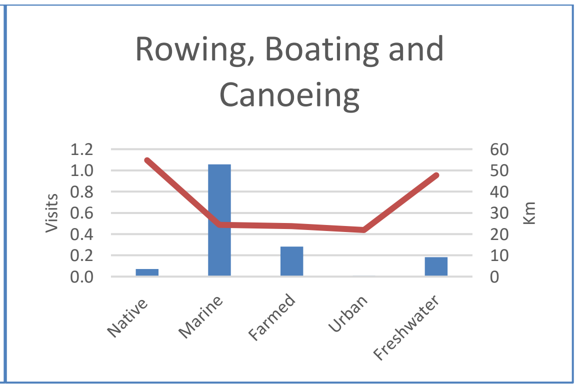

Fishing
Visits
Km
1.0
0.8
0.6
0.4
0.2
0.0
80
60
40
20
0
Native
Marine
Farmed
Urban
Freshwater

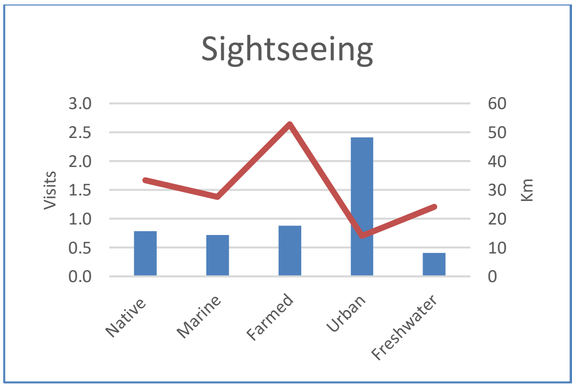

Hunting
Visits
Km
0.30
0.25
0.20
0.15
0.10
0.05
0.00
70
60
50
40
30
20
10
0
Native
Marine
Farmed
Urban
Freshwater


Mountain Biking
Visits
Km
1.0
0.8
0.6
0.4
0.2
0.0
40
35
30
25
20
15
10
5
0
Native
Marine
Farmed
Urban
Freshwater


Nature and Birdwatching
Visits
Km
8
7
6
5
4
3
2
1
0
10
8
6
4
2
0
Native
Marine
Farmed
Urban
Freshwater


Picnicking
Visits
Km
2.0
1.5
1.0
0.5
0.0
30
25
20
15
10
5
0
Native
Marine
Farmed
Urban
Freshwater


Rowing, Boating and Canoeing
Visits
Km
1.2
1.0
0.8
0.6
0.4
0.2
0.0
60
50
40
30
20
10
0
Native
Marine
Farmed
Urban
Freshwater


Sightseeing
Visits
Km
3.0
2.5
2.0
1.5
1.0
0.5
0.0
60
50
40
30
20
10
0
Native
Marine
Farmed
Urban
Freshwater

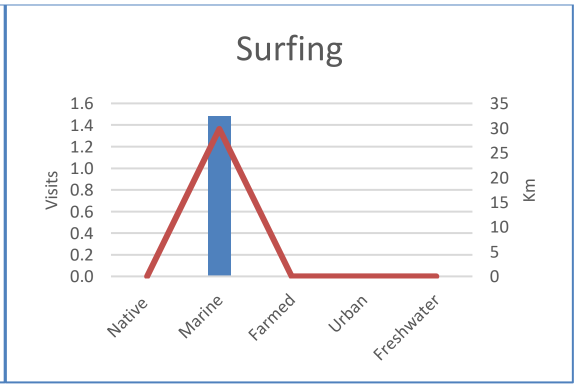

Surfing
Visits
Km
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
35
30
25
20
15
10
5
0
Native
Marine
Farmed
Urban
Freshwater

Figure 3.8: Average visits and distance travelled for activities across environment types in the last 12 months.

3.3 Choice Experiment Results

The aggregate utility function describing public preferences for biodiversity outcomes (Table 2) is estimated using a Random Parameters Logit (RPL) specification (see Appendix B for technical details). This type of model exemplifies a contemporary approach with a relatively flexible form. Notably, the ability to allow parameter estimates to vary over respondents, rather than being held constant, reflects the degree of heterogeneity in preferences over native biodiversity outcomes in the general population. This is an important modelling consideration as the debate over the management of native biodiversity resources shows many different points of view that need to be accommodated within modelling.

When making their choices, some respondents may select the 'current biodiversity management' option in a choice task as a truthful indication of their *unwillingness to pay* for improvements to New Zealand biodiversity. However, respondents who chose the no management option in every choice task may be exhibiting protest behavior, and therefore not truthfully revealing their preferences for biodiversity quality outcomes. Protest behaviour is relatively common in these types of surveys and is typically for reasons associated with the process of valuation such as the type of good being valued and who is being asked to pay for the good. Respondents who consistently chose this no cost option (8 per cent of the sample, n = 85) were asked a follow-up question to ascertain their reasons for being averse to paying for native biodiversity improvements (Figure 11).

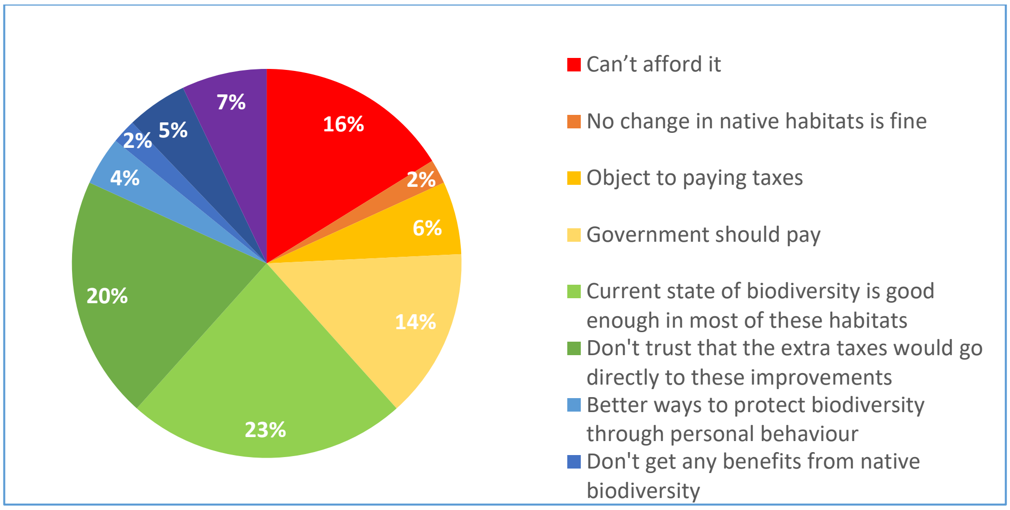


Figure 3.9 Reasons why respondents always chose the 'current native biodiversity management' option in choice tasks.

The majority of this group comprised protest responses (49 per cent). These respondents don't trust that the extra taxes would go directly to these improvements (20 per cent); considered that the government should pay (14 per cent); object to paying taxes (6 per cent); would be willing to pay something but not via taxes (5 per cent); or think there are better ways to protect biodiversity through their personal activity (4 per cent). Some respondents indicated that they cannot afford to pay for native biodiversity improvements (16 per cent). Some respondents consider that they do not get any benefits from improving native biodiversity quality (27 per cent). These respondents believe the current state of biodiversity in good enough in most of these habitats (23 per cent); don't get any benefits from native biodiversity (2 per cent); believe that no change in native habitats is fine (2 per cent). Respondents who are identified as protest responses are excluded from statistical modeling of preferences for native biodiversity management outcomes. Auxiliary analysis not reported here found no statistically significant impact on modelling results from those stated.

Table 3.3: Model variables

Native forest quality - Moderate	Moderate native biodiversity outcomes in native forests
Native forest quality - Good	Good native biodiversity outcomes in native forests
Farmed landscapes quality - Moderate	Moderate native biodiversity outcomes in farmed landscapes
Farmed landscapes quality - Good	Good native biodiversity outcomes in farmed landscapes
Lowland freshwater quality - Moderate	Moderate native biodiversity outcomes in lowland freshwater
Lowland freshwater quality - Good	Good native biodiversity outcomes in lowland freshwater
Marine quality - Moderate	Moderate native biodiversity outcomes in marine
Marine quality - Good	Good native biodiversity outcomes in marine
Urban quality - Moderate	Moderate native biodiversity outcomes in urban
Urban quality - Good	Good native biodiversity outcomes in lowland urban
Annual tax contribution	\$0, \$25, \$50, \$100, \$150 per person per year
Current native biodiversity outcomes	1 if current outcomes, 0 otherwise
Children in household	Number of persons in household ≤18 years old
Income	Personal gross annual income
Current biodiversity quality very low	Respondent considers current level of biodiversity quality as very low
Environmental behaviour	Number of biodiversity supporting activities (0 to 6)
Native forest activities*Moderate	Interaction of annual number of native forest activities with moderate level of native forest attribute
Native forest activities*Good	Interaction of annual number of native forest activities with good level of native forest attribute
Farmed landscapes activities*Moderate	Interaction of annual number of farmed landscape activities with moderate level of farmed landscape attribute
Farmed landscapes activities*Good	Interaction of annual number of farmed landscape activities with good level of farmed landscape attribute
Lowland freshwater activities*Moderate	Interaction of annual number of lowland freshwater activities with moderate level of lowland freshwater attribute
Lowland freshwater activities*Good	Interaction of annual number of lowland freshwater activities with good level of lowland freshwater attribute
Marine activities*Moderate	Interaction of annual number of marine activities with moderate level of marine attribute
Marine activities*Good	Interaction of annual number of marine activities with good level of marine attribute
Urban activities*Moderate	Interaction of annual number of urban activities with moderate level of urban attribute
Urban activities*Good	Interaction of annual number of urban activities with good level of urban attribute
Native forest activites^2*Moderate	Interaction of annual number of native forest activities-*squared* with moderate level of native forest attribute
Native forest activites^2*Good	Interaction of annual number of native forest activities-*squared* with good level of native forest attribute
Farmed landscapes activites^2*Moderate	Interaction of annual number of farmed landscape activities-*squared* with moderate level of farmed landscape attribute
Farmed landscapes activites^2*Good	Interaction of annual number of farmed landscape activities-*squared* with good level of farmed landscape attribute
Lowland freshwater activites^2*Moderate	Interaction of annual number of lowland freshwater activities-*squared* with moderate level of lowland freshwater attribute
Lowland freshwater activites^2*Good	Interaction of annual number of lowland freshwater activities-*squared* with good level of lowland freshwater attribute
Marine activites^2*Moderate	Interaction of annual number of marine activities-*squared* with moderate level of marine attribute
Marine activites^2*Good	Interaction of annual number of marine activities-*squared* with good level of marine attribute
Urban activites^2*Moderate	Interaction of annual number of urban activities-*squared* with moderate level of urban attribute
Urban activites^2*Good	Interaction of annual number of urban activities-*squared* with good level of urban attribute

By conventional statistical standards, the model performs well (Table 6). All the biodiversity quality attributes are statistically significant, meaning that they are important factors in resident's choice of biodiversity management option. The model predicts how respondents choose a particular management option based on the outcomes and costs associated with that option. The parameter estimates tell us how an attribute relates to the overall utility of residents from the benefits of native biodiversity management. Respondents are more likely to choose a management option that has good quality outcomes, while they are less likely to choose options imposing greater financial contributions.

The model generates a normal distribution of parameter estimates for each random parameter with the mean reported, and the standard deviation of the distribution. A larger magnitude of the standard deviation of the distribution indicates a relatively larger degree of preference differences across respondents for that biodiversity outcome. For example, respondents have the most similar preferences for native biodiversity outcomes in urban environments (as the s.d. is insignificant). This means that respondents typically responded in the same way when presented with changes in urban native biodiversity outcomes. While preferences for improvements in marine environments are not as consistent across respondents as shown by larger standard deviations, meaning that some respondents prefer no improvements while others have a strong preference for improvements.

Modelling shows that the number of times respondents engage in activities in each environment type is a key influence on their preferences for native biodiversity outcomes in those environments. The influence on preferences increases as the number of times respondents engage increases.

Other findings include:

- There is a strong preference overall for expanding native biodiversity management over current outcome levels.
- Those with children are more likely to choose a management option that improves biodiversity outcomes than those that do not.
- Those on relatively higher incomes are more likely to choose a management option that improves biodiversity outcomes.
- Those that believe current native biodiversity outcomes to be very low are more likely to choose a management option that improves biodiversity outcomes, than those that do not.
- Those that participate in biodiversity supporting activities are more likely to choose a management option that improves biodiversity outcomes than those that do not.

Table 3.4: Choice model estimates

	Parameter mean estimates		Standard deviation of random parameters	
Random parameters in utility function				
Native forest quality - Moderate	0.173***	(0.06)	0.846***	(0.14)
Native forest quality - Good	0.830***	(0.07)	0.846***	(0.14)
Farmed landscapes quality - Moderate	0.128**	(0.08)	1.529***	(0.23)
Farmed landscapes quality - Good	0.662***	(0.07)	0.098	(0.61)
Lowland freshwater quality - Moderate	0.389***	(0.08)	1.080***	(0.12)
Lowland freshwater quality - Good	0.642***	(0.09)	1.080***	(0.12)
Marine quality - Moderate	0.363***	(0.09)	1.484***	(0.14)
Marine quality - Good	0.791***	(0.10)	1.484***	(0.14)
Urban quality - Moderate	0.124**	(0.05)	0.141	(0.39)
Urban quality - Good	0.678***	(0.12)	0.141	(0.39)
Annual tax contribution -	0.025***	(0.00)	0.025***	(0.00)
Nonrandom parameters in utility function				
Current native biodiversity outcomes -	1.644***	(0.35)		
Children in household	1.751***	(0.41)		
Income	0.219*	(0.12)		
Current biodiversity quality very low	0.531***	(0.14)		
Environmental behaviour	0.999***	(0.19)		
Native forest activities*Moderate	0.006*	(0.00)		
Native forest activities*Good	0.018***	(0.00)		
Farmed landscapes activities*Moderate	0.005***	(0.00)		
Farmed landscapes activities*Good	0.012***	(0.00)		
Lowland freshwater activities*Moderate	0.021***	(0.00)		
Lowland freshwater activities*Good	0.023***	(0.00)		
Marine activities*Moderate	0.015***	(0.00)		
Marine activities*Good	0.007	(0.01)		
Urban activities*Moderate	0.004***	(0.00)		
Urban activities*Good	0.010***	(0.00)		
Native forest activites2*Moderate	0.19e-4	(0.14e-4)		
Native forest activites2*Good	0.77e-4***	(0.17e-4)		
Farmed landscapes activites2*Moderate	0.12e-4	(0.88e-5)		
Farmed landscapes activites2*Good	0.58e-4**	(0.23e-5)		
Lowland freshwater activites2*Moderate	0.17e-3***	(0.21e-4)		
Lowland freshwater activites2*Good	0.23e-3***	(0.20e-4)		
Marine activites2*Moderate	0.11e-4	(0.19e-4)		
Marine activites2*Good	0.26e-4**	(0.19e-4)		
Urban activites2*Moderate	0.23e-3**	(0.11e-4)		
Urban activites2*Good	0.26e-3***	(0.32e-5)		
Latent random effects between no-current options	4.699***	(0.28)		
Model Fit Statistics				
Log Likelihood function -	4,472			
Log Likelihood chi^2 stat (40 d.f.)	3,376***			
McFadden Pseudo R^2	0.43			
Number of observations	5,608			

Note: ***, **,* denote statistical significance at the 1 per cent, 5 per cent and 10 per cent levels respectively for the null hypothesis that a parameter estimate is not significantly different from zero. Standard errors in brackets.

The standard statistical model assumes that all the information that a respondent sees in a choice set has a role to play in determining the respondents' choice of option. If respondents ignore some of the native biodiversity management outcomes when they select their preferred option, this assumption is weakened and requires further examination. Following each choice task, respondents were asked to indicate which, if any, of the native biodiversity management outcomes being considered, did they ignore (Fig. 12). Each outcome is ignored to a similar degree, at what can be considered to be a relatively low level. To determine whether incorporating this information improves statistical modelling we fit a stated attribute non-attendance model as is best-practice; we find no qualitative improvement on the results presented in Table 6.

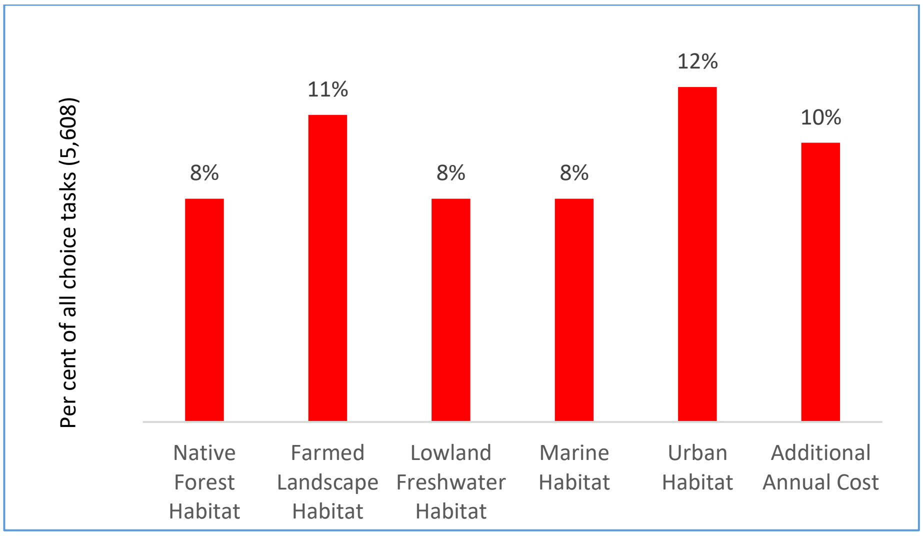


Figure 3.10: Native biodiversity management outcomes ignored by respondents in choice tasks

Following each choice task, we ask a series of questions (Figure 13) to identify sources of variance in the random component of utility. For example, respondents who find the choices difficult to make often exhibit greater variability in the way they make their choices compared to other respondents who do not find it difficult, that cannot be attributed to the levels of the biodiversity outcomes presented to them. The GMXL model (see Appendix B for details) allows for modelling of unobserved influences on respondents choice variation. This is useful as sources of modelling heterogeneity may be coming from factors other than respondent preferences for the biodiversity outcomes presented to them. While we do find that respondents who find the choice task relatively easy to answer or that understood the choice task exhibit lower choice error, the RPL model outperforms the GMXL model and so is retained as the preferred specification.

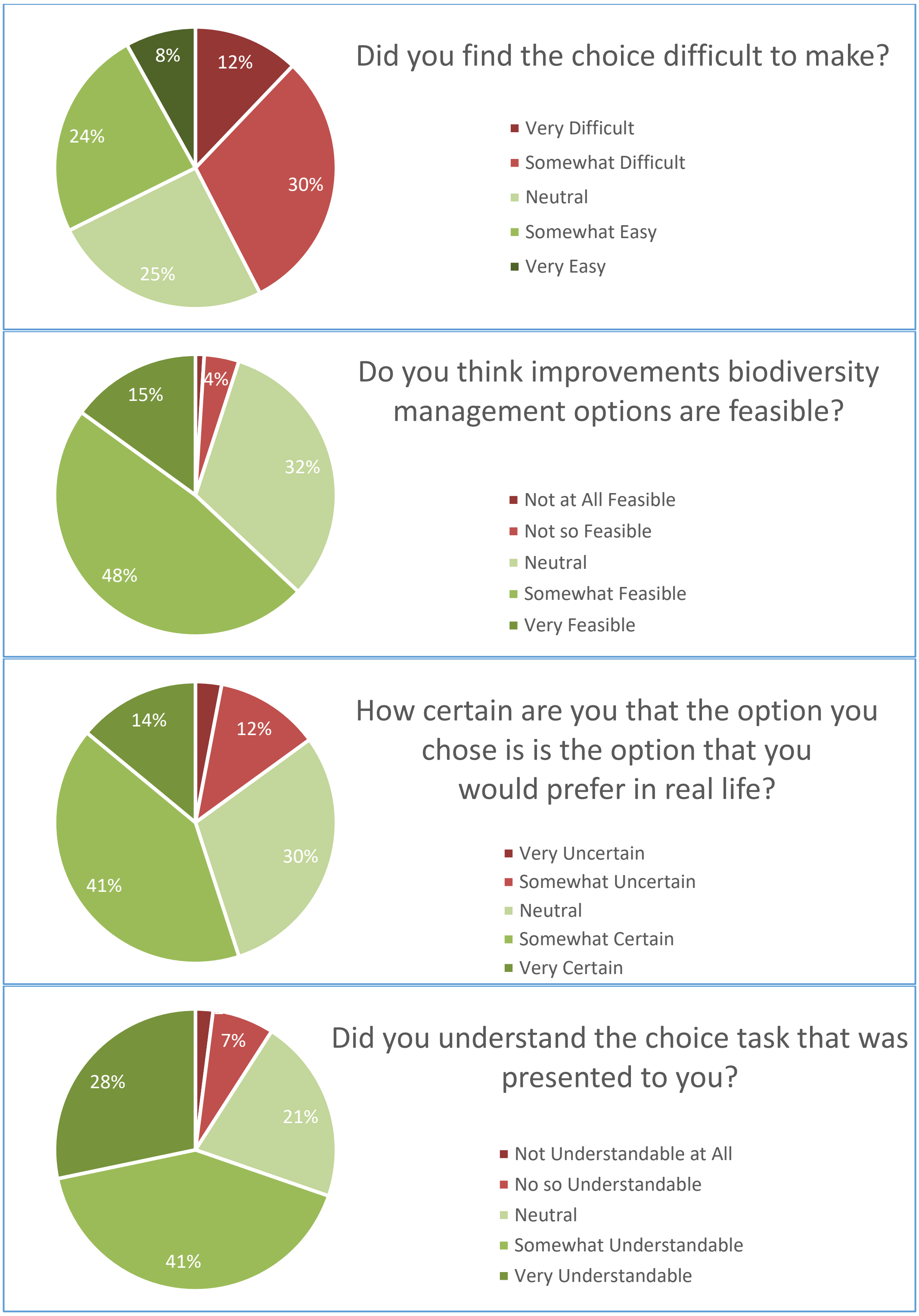


Figure 3.11: Native biodiversity management choice task debriefing questions: Difficulty, understanding, certainty, and feasibility.

A further CE debriefing question asked respondents to indicate their preference's over the location of any biodiversity improvements depicted in the choice tasks. Respondents' were asked 'where would you prioritise improvements to occur? (Fig. 14). Some key observations are:

- A majority of respondents were happy for biodiversity improvements to occur anywhere in NZ.
- Urban biodiversity improvements were more likely to be preferred in areas close to respondents abode.

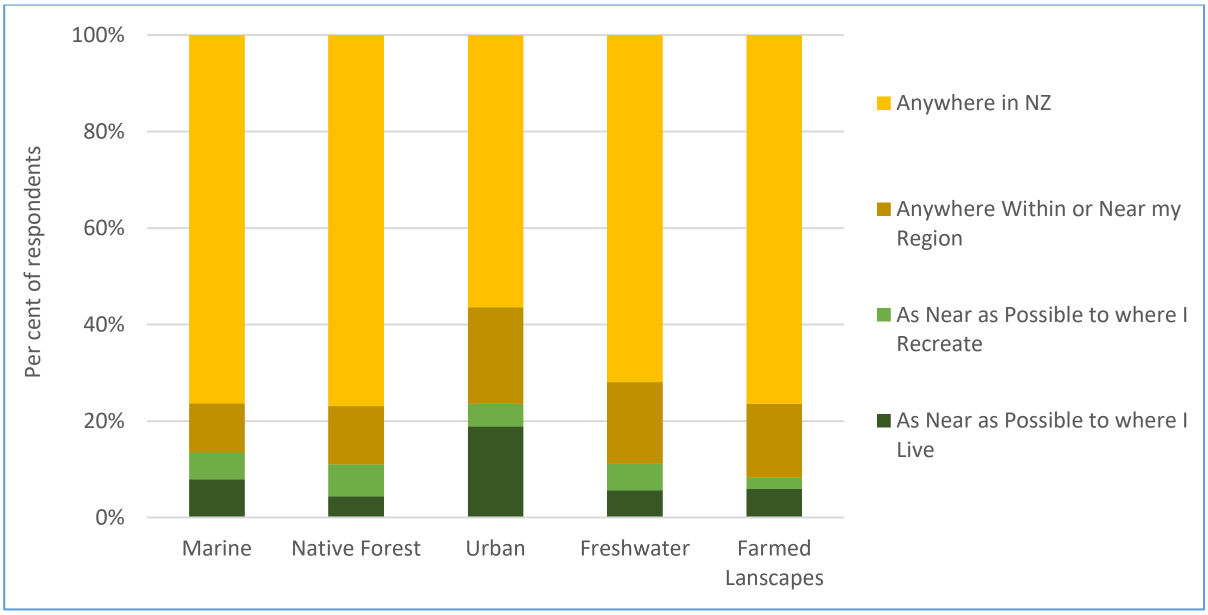


Figure 3.12: Respondent preferences for location of biodiversity improvements

The observation that respondents were happy for improvements to occur anywhere in NZ may reflect the strong public good characteristics of biodiversity outcomes. We explore whether respondents viewed the biodiversity outcomes presented in the choice tasks as private or public benefits. They were asked to indicate the balance between private and public benefits that they considered native biodiversity improvements provide by sliding a marker across to the appropriate value (Figure 15).

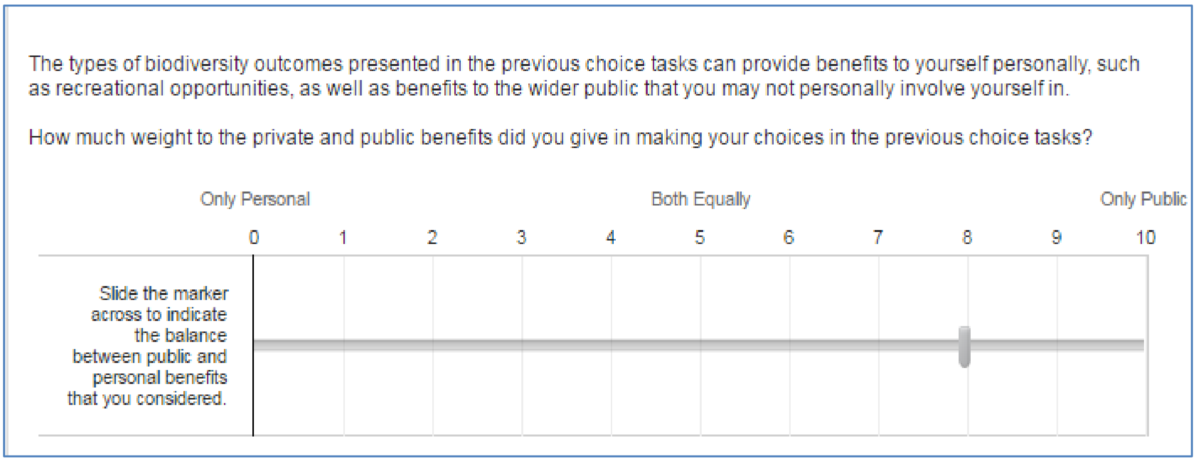


Figure 3.13. Format of question concerning biodiversity outcomes as public or private benefits

The distribution of responses (Fig. 16) reveals that:

- 15 per cent of respondents considered biodiversity outcomes to provide **mostly private** benefits.
- 43 per cent of respondents considered biodiversity outcomes to provide public and private benefits **equally.**
- 42 per cent of respondents considered biodiversity outcomes to provide **mostly public** benefits.

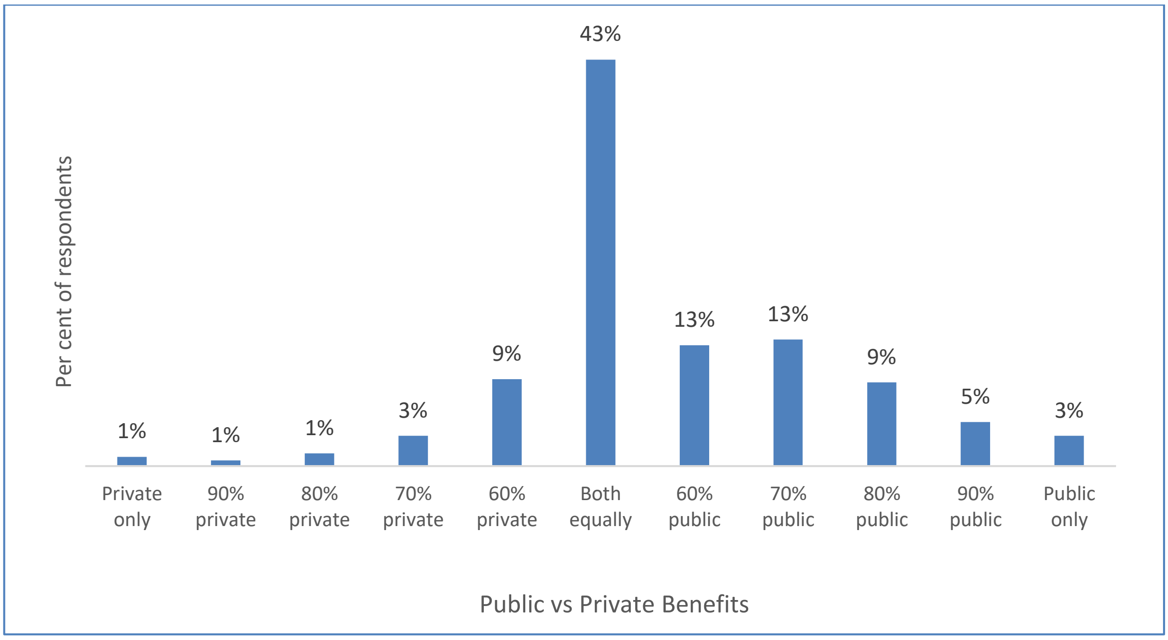


Figure 3.14: Respondent consideration of biodiversity outcomes as public or private benefits

3.4 Monetary Value of Benefits

Applying the model estimates (Table 6) and equation 1.1 (Appendix B) generates estimates of respondents WTP for native biodiversity outcomes. WTP is an estimate of how much money a respondent would be willing to give up for a change in the relevant biodiversity quality outcome and is calculated using the ratio of an attribute parameter and the cost parameter.

Two sets of WTP estimates are calculated to illustrate the importance of including the influence on preferences of respondent's engagement with environment types (Table 7). The first set of estimates ignores respondent's level of engagement with environment types in the valuation calculation, while the second includes the value of this engagement in the calculation based on the average number of visits (Fig. 9).

- **For respondents who do not participate in any activities in the five environments considered here:** good outcomes in marine environments are valued highest, closely followed by good outcomes in native forest.
- **For the average respondent level of activities:** good outcomes in urban environments are valued highest, followed by good outcomes in marine and native forest environments.

Table 3.5: Willingness to pay for native biodiversity outcomes

Native biodiversity outcomes across environments	WTP ($) **without** environment engagement	WTP ($) **with** environment engagement
Native Forest: Moderate outcomes	54(22,124)	56(24,130)
Native Forest: Good outcomes	82(43,162)	89(28,175)
Farmed Landscapes: Moderate outcomes	40(7,112)	46(11,122)
Farmed Landscapes: Good outcomes	62(36,116)	75(47,139)
Lowland Freshwater: Moderate outcomes	65(26,151)	69(28,159)
Lowland Freshwater: Good outcomes	73(33,164)	78(35,174)
Marine: Moderate outcomes	73(20,173)	80(26,197)
Marine: Good outcomes	87(34,198)	91(35,213)
Urban: Moderate outcomes	22(16,33)	54(42,79)
Urban: Good outcomes	53(43,78)	99(80,145)

Note: $NZ 2015 Median (25th percentile, 75th percentile)

Examining the distributions of WTP estimates reveals that native biodiversity outcomes in marine environments exhibit the largest range of values, while outcomes in urban environments exhibit the least (Fig. 17). This suggests that:

- Public preferences are ***most*** diverse for native biodiversity outcomes in marine environments. Suggesting a relatively larger degree of disagreement over management outcomes.
- Public preferences are ***least*** diverse for native biodiversity outcomes in urban environments. Suggesting a relatively larger degree of consensus for management outcomes.

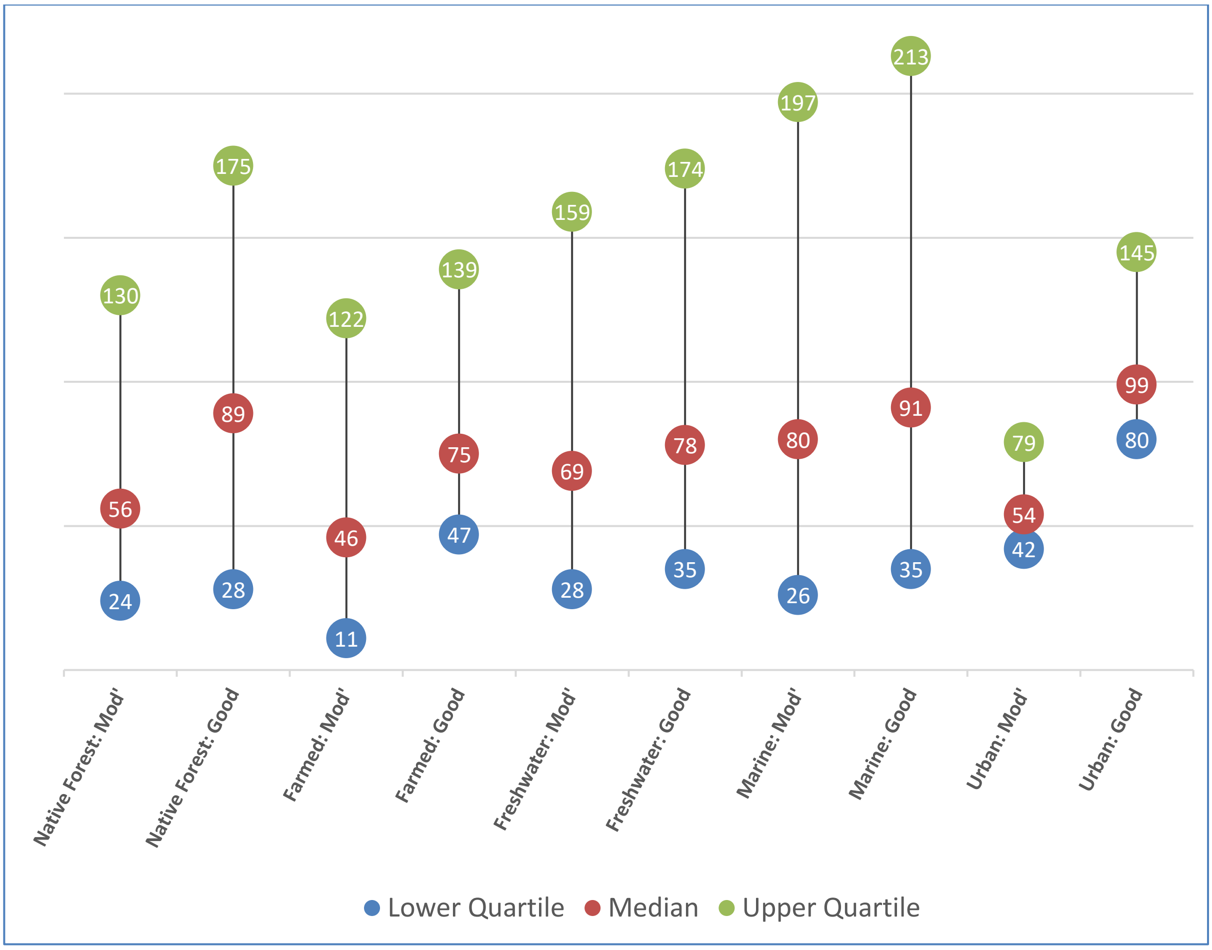


Figure 3.15: Distributions of WTP for native biodiversity outcomes

Chapter 4
Conclusions

Within a national context of increasingly competing demands for limited biodiversity management resources, a central research question in concerns the allocation of resource efficiently across the portfolio of programs. A central objective of this report was to apply economic method to aid biodiversity decision makers in addressing this research question. While the direct costs associated with native biodiversity management are observable in market transactions, such as the costs of pest control, many of the benefits do not have associated market signals with which to measure the value of native biodiversity outcomes. This report applied the economic non-market valuation approach of choice experiments, to estimate the value that New Zealand residents place on native biodiversity outcomes across different environments. The WTP results found here are consistent with those of comparable choice experiment studies, finding significant public support for enhancement of native biodiversity outcomes. Central conclusions include:

- The survey process achieved a sample of 985 respondents demographically representative of the NZ population.
- Respondents thought that current native biodiversity quality was highest in native forests, and lowest in urban environments.
- Protecting endangered biodiversity is a significant or very important consideration (87 per cent) when allocating management effort across biodiversity programs. As is protecting biodiversity that impacts on human health (81 per cent).
- Polluter-pays principle is supported as part of management approaches, 83 per cent agree or strongly agree that stronger rules should be made into law to help change biodiversity damaging behaviour from polluting industries.
- Levying international tourists to fund biodiversity management was the least favored tool considered, however, 44 per cent of respondents still agree or strongly agree that international tourists should pay a levy.
- Respondents overall have a strong preference for expanding native biodiversity management over current levels. 90 per cent were willing to pay something to improve native biodiversity outcomes.
- The public has a high level of active engagement with natural environments. In the last 12 months the average respondents visited:
    - Urban environments 46 times
    - Farmed landscape environments 25 times
    - Marine environments 10 times
    - Native forest environments 9
    - Lowland freshwater environments 3 times
- Overall, respondents prefer biodiversity improvements to occur anywhere in NZ. However, urban biodiversity improvements were more likely to be preferred in areas close to respondents home.
- The level of engagement that a respondent has with different environments is an important determinant in how they value native biodiversity outcomes in those environments.
- The median respondent is willing to pay the most for native biodiversity outcomes in urban environments. Willingness to pay per year is:

- $99 for good quality outcomes in urban environments, and $54 for moderate quality outcomes
- $91 for good quality outcomes in marine environments, and $80 for moderate quality outcomes
- $89 for good quality outcomes in native forest environments, and $56 for moderate quality outcomes
- $78 for good quality outcomes in lowland freshwater environments, and $69 for moderate quality outcomes
- $75 for good quality outcomes in farmed environments, and $46 for moderate quality outcomes

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Appendix A
LCDB Class Groupings

LCDB Class Name 2012	Environment Type
Built-up Area (settlement)	Urban
Urban Parkland/Open Space	Urban
Transport Infrastructure	Urban
Surface Mine or Dump	Unclassified
Sand or Gravel	Marine
Landslide	Unclassified
Permanent Snow and Ice	Unclassified
Alpine Grass/Herbfield	Unclassified
Gravel or Rock	Unclassified
Lake or Pond	Freshwater
River	Freshwater
Estuarine Open Water	Marine
Short-rotation Cropland	Farmed
Orchard, Vineyard or Other Perennial Crop	Farmed
High Producing Exotic Grassland	Farmed
Low Producing Grassland	Farmed
Tall Tussock Grassland	Native
Depleted Grassland	Farmed
Herbaceous Freshwater Vegetation	Freshwater
Herbaceous Saline Vegetation	Marine
Flaxland	Native
Fernland	Native
Gorse and/or Broom	Unclassified
Manuka and/or Kanuka	Native
Broadleaved Indigenous Hardwoods	Native
Sub Alpine Shrubland	Native
Mixed Exotic Shrubland	Unclassified
Matagouri or Grey Scrub	Native
Forest - Harvested	Farmed
Deciduous Hardwoods	Farmed
Indigenous Forest	Native
Mangrove	Marine
Exotic Forest	Farmed

Appendix B
Statistical Method

This appendix provides technical details of statistical analysis of choice data. The appendix includes a brief description of the theoretical foundations of choice analysis followed by statistical probability estimation approaches, focusing on contemporary models applied in this report. Lastly, the method used in generating monetary estimates is described.

B.1 Conceptual Framework

In Choice Experiments (CEs), researchers are interested of what influences, on average, the survey respondents' decisions to choose one alternative over others. These influences are driven by people's preferences towards the attributes but also the individual circumstances such as their demographics or perceptions of the choice task (e.g., the level of difficulty or understanding) (Hensher et al. 2015).

Each alternative in a choice set is described by attributes that differ in their levels, both across the alternatives and across the choice sets. The levels can be measured either qualitatively (e.g., poor and good) or quantitatively (e.g., kilometres). This concept is based on the characteristics theory of value (Lancaster 1966) stating that these attributes, when combined, provide people a level of utility[15] *U* hence providing a starting point for measuring preferences in CE (Hanley et al. 2013; Hensher et al. 2015). The alternative chosen, by assumption, is the one that maximises people's utility[16] providing the behavioural rule underlying choice analysis:

$$U_j > U_i \tag{1.1}$$

where the individual *n* chooses the alternative *j* if this provides higher utility than alternative *i*. A cornerstone of this framework is Random Utility Theory, dated back to early research on choice making (e.g., Thurstone 1927) and related probability estimation. This theory postulates that utility can be decomposed into systematic (explainable or observed) utility *V* and a stochastic (unobserved) utility ε (Hensher et al. 2015; Lancsar and Savage 2004).

$$U_{nj} = V_{nj} + \varepsilon_{nj} \tag{1.2}$$

where *j* belongs to a set of J alternatives. The importance of this decomposition is the concept of utility only partly being observable to the researcher, and remaining unobserved sources of utility can be treated as random (Hensher et al. 2015). The observed component includes information of the attributes as a linear function of them and their preference weights (coefficient estimates).

[15]Related terminology used in psychology discipline is *the level of satisfaction* (Hensher et al. 2015).
[16]In choice analysis, utility is considered as *ordinal utility* where the relative values of utility are measured (Hensher et al. 2015).

$$V_{nsj} = \sum_{k=1}^{K} \beta_k x_{nsjk} \tag{1.3}$$

with *k* attributes in vector x for a choice set s. Essentially, the estimated parameter β shows "the effect on utility of a change in the level of each attribute" (Hanley et al. 2013, p. 65). This change can be specified as linear across the attribute levels, or as non-linear using either dummy coding or effect coding approaches. The latter coding approach has a benefit of not confounding with an alternative specific constant (ASC) when included in the model (Hensher et al. 2015).

B.2 Statistical Modelling of Choice Probabilities

The statistical analysis aims to explain as much as possible of the observed utility using the data obtained from the CE and other relevant survey data. In order to do so, the behavioural rule (eq. 1.1) and the utility function (eq. 1.2) are combined (Hensher et al. 2015; Lancsar and Savage 2004) to estimate the probability of selecting an alternative *j*:

$$\Pr_{nsj} = \Pr\left(U_{nsj} > U_{nsi}\right) = \Pr\left(V_{nsj} + \varepsilon_{nsj} > V_{nsi} + \varepsilon_{nsi}\right) = \Pr\left(\varepsilon_{nsi} - \varepsilon_{nsj} < V_{nsj} - V_{nsi}\right) \forall j \neq i \tag{1.4}$$

where the probability of selecting alternative *j* states that differences in the random part of utility are smaller than differences in the observed part. A standard approach to estimate this probability is a conditional logit, or multinomial logit (MNL) model (McFadden 1974). This model can be derived from the above equations (1.2 and 1.3) by assuming that the unobserved component is independently and identically distributed (IID) following the Extreme Value type 1 distribution (see e.g. Hensher et al. 2015; Train, 2003). Although the MNL model provides a "workhorse" approach in CE, it includes a range of major limitations (see e.g. Fiebig et al. 2010; Greene and Hensher 2007; Hensher et al. 2015):

- Restrictive assumption of the IID error components
- Systematic, or homogenous, preferences allowing no heterogeneity across the sample
- Restrictive substitution patterns, namely the existence of independence of irrelevant alternatives property where introduction (or reduction) of a new alternative would not impact on the relativity of the other alternatives
- The fixed scale parameter obscures potential source of variation

Some or all of these assumptions are often not realised in collected data. These restrictive limitations can be relaxed in contemporary choice models. In particular, the random parameter logit (RPL) model (aka, the mixed logit model) has emerged in empirical application allowing preference estimates to vary across respondents (Fiebig, et al. 2010; Hensher et al. 2015; Revelt and Train, 1998). This is done by specifying a known distribution of variation to be parameter means. The RPL model probability of choosing alternative *j* can be written as:

$$\Pr_{nsj} = \frac{\exp(\beta_n^{'} x_{nsj})}{\sum_J \exp(\beta_n^{'} x_{nsj})} \tag{1.5}$$

where, in the basic specification, $\beta_n = \beta + \eta_n$ with *η* being a specific variation around the mean for *k* attributes in vector *x* (Fiebig, et al. 2010; Hensher et al. 2015). Typical distributional assumptions for the random parameters include normal, triangular and lognormal distributions, amongst others. The normal distribution captures both positive and negative preferences (i.e., *utility* and *disutility*) (Revelt and Train, 1998). The lognormal function can be used in cases where the researcher wants to ensure the parameter has a certain sign (positive or negative), a disadvantage is the resultant long tail of estimate distributions (Hensher et al. 2015). The triangular distribution provides an alternative functional form, where the spread can be constrained (i.e., the mean parameter is free whereas spread is fixed equal to mean) to ensure behaviourally plausible signs in estimation (Hensher et al. 2015). Further specifications used in modelling include parameters associated with individual specific characteristics (e.g, income) that can influence the heterogeneity around the mean, or allowing correlation across the random parameters. The heterogeneity in mean, for example, captures whether individual specific characteristics influence the location of an observation on the random distribution (Hensher et al. 2015). In this study, the frequency of visits to rivers, streams and lakes was used to explain such variance.

Another way to write this probability function (in eq. 1.4) (Hensher et al. 2015) involves an integral of the estimated likelihood over the population:

$$L_{njs} = \int_{\beta} \mathrm{Pr}_{nsj}\left(\beta\right) f\left(\beta \middle| \theta\right) d\beta \qquad (1.6)$$

In this specification, the parameter θ is now the probability density function conditional to the distributional assumption of β. As this integral has no closed form solution, the approximation of the probabilities requires a simulation process (Hensher et al. 2015; Train, 2003). In this process for data *X*, *R* number of draws are taken from the random distributions (i.e. the assumption made by the researcher) followed by averaging probabilities from these draws; furthermore these simulated draws are used to compute the expected likelihood functions:

$$L_{nsj} = E(\mathrm{Pr}_{nsj}) \approx \frac{1}{R} \sum_{R} f(\beta^{(r)} \mid X) \qquad (1.7)$$

where the $E(\mathrm{Pr}_{nsj})$ is maximised through Maximum Likelihood Estimation. This specification (in eq. 1.6) can be found in Hensher et al. (2015). In practice, a popular simulation method is the Halton sequence which is considered a systematic method to draw parameters from distributions compared to for example, pseudo-random type approaches (Hensher et al. 2015).

B.3 Econometric Extensions

Common variations of the RPL model include specification of an additional error component (EC) in the unobserved part of the model. This EC extension captures the unobserved variance that is alternative-specific (Greene and Hensher 2007) hence relating to substitution patterns between the alternatives

(Hensher et al. 2015). Empirically, one way to explain significant EC in a model is SQ-bias depicted in the stochastic part of utility if the EC is defined to capture correlation between the non-SQ alternatives (Scarpa et al., 2005).

Another extension which has gained increasing attention in recent CE literature, is the Generalized Mixed Logit (GMXL) model (Czajkowski et al. 2014; Hensher et al. 2015; Juutinen et al. 2012; Kragt 2013; Phillips 2014). This model aims to capture remaining unobserved components in utility as a source of choice variability by allowing estimation of the scale heterogeneity alongside the preference heterogeneity (Fiebig et al. 2010; Hensher et al. 2015). This scale parameter is (inversely) related to the error variance, and in convenient applications such as MNL or RPL, this is normalised to one to allow identification (Fiebig et al. 2010; Louviere and Eagle 2006). However, it is possible that the level of error variance differs between or within individuals, due to reasons such as behavioural outcomes, individual characteristics or contextual factors (Louviere and Eagle 2006).

Recent GMXL application builds on model specifications presented in Fiebig et al. (2010), stating that β_n (in eq. 1.4) becomes:

$$\beta_n = \sigma_n \beta + \gamma \eta_n + (1-\gamma)\sigma_n \eta_n \tag{1.8}$$

where σ is the scale factor (typically = 1) and $\gamma \in \{0,1\}$ is a weighting parameter indicating variance in the residual component. In the case the scale factor equals 1, this reduces to the RPL model. The importance of the weighting parameter is the impact on the scaling effect on the overall utility function (population means) versus the individual preference weights (individual means): when γ parameter approaches zero the scale heterogeneity affects both means, whereas when this approaches one the scale heterogeneity affects only the population means (Hensher et al. 2015; Juutinen et al. 2015). Interpretation of these parameters includes

- If γ is close to zero, and statistically significant, this supports the model specification with the variance of residual taste heterogeneity increases with scale (Juutinen et al. 2012); and
- If γ is not statistically significant from one, this suggests that the unobserved residual taste heterogeneity is independent of the scale effect, that is the individual-level parameter estimates differ in means but not variances around the mean (Kragt, 2013)

The scale factor specification (eq. 1.7) can also be extended to respondent specific characteristics associated with the unobserved scale heterogeneity (Hensher et al. 2015; Juutinen et al. 2015):

$$\sigma_n = \exp\{\overline{\sigma} + \tau \omega_n\} \tag{1.9}$$

where $\overline{\sigma}$ *is* the mean parameter in the error variance; and ω is unobserved scale heterogeneity (normally distributed) captured with coefficient τ (Hensher et al. 2015; Juutinen et al. 2015; Kragt, 2013).

Juutinen et al. (2012), for example, in context of natural park management found that respondents' education level and the time spent in the park explained the scale heterogeneity ($\tau > 0$, p-value < 0.01). In this study, the respondents indicated levels of choice task understanding and difficulty were used to explain scale heterogeneity.

B.4 Estimation of Monetary Values

Typically the final step of interest in the CE application is the estimation of monetary values of respondent preferences for the attributes considered in utility functions. These are commonly referred to as marginal willingness-to-pay (WTP). WTP estimation is based on the marginal rate of substitution expressed in dollar terms providing a trade-off between some attribute k and the cost involved (Hensher et al. 2015) and is calculated using the ratio of an attribute parameter and the cost parameter. WTP can take into account interaction effects, if statistically significant, such as with the respondent demographics. WTP of attribute *j* by respondent *i* is calculated as the ratio of the estimated model parameters accommodating the influence of the random component (Cicia et al. 2013) as:

$$WTP_i^j = -\left(\frac{\beta_j + \varepsilon_{ij}}{\beta_{price} + \varepsilon_{ip}} \right) \tag{1.10}$$

The estimated mode parameters can also be used to estimate compensating surplus (CS) as a result of policy or quality change in a combination of attributes, using (Hanemann, 1984):

$$\mathbf{CS} = \frac{-1}{\beta cost} \left[\ln \sum_{j=1}^{J} \exp\left\{V_j^0\right\} - \ln \sum_{j=1}^{J} \exp\left\{V_j^1\right\} \right] \tag{1.11}$$

which calculates the difference in utilities before the policy or quality change (V_0) and after the policy or quality change (V_1) (Hanley et al. 2013; Lancsar and Savage 2004). Similar to WTP, the monetary estimation of this change is possible by using the estimate for the monetary attribute $\beta_{cost.}$. Lastly, there are some challenges associated with the empirical estimation of the WTP in the RPL based models. One approach is to use a fixed cost, which simplifies the WTP estimation (Daly et al. 2012) but which may not be as behaviourally a plausible consideration as allowing heterogeneous preferences towards the cost attribute (Bliemer and Rose, 2013; Daziano and Achtnicht, 2014). Conceptually, the estimated cost parameter is a proxy for the marginal utility of income for respondents and economic theory suggests individuals will respondent differently to varying income levels. The use of a random cost parameter however, presents complications in deriving population distribution moments from the ratio of two random parameters.

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